DEC 7 1922

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ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY WILLIAM H. MAW AND ALEX. RICHARDSON.

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See page 17, Nov. 17. 9047

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See half page advert., page 60, Nov. 10. 8195

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See Full Page Advt., page 55, Nov. 10.

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See Advt. Page 13 Nov. 17.
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Steam and Friction
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Instruction (with instruments) in CHAIN, COMPASS and THEODOLITE SURVEYING and LEVELLING. Theoretical CLASSES NOW COMMENCING.—APPLY AT ONCE to the Director of Instruction, J. WHITE, B.Sc. (Eng.), Hons. Lond.
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Tel.:—Victoria 4411. W 826

The Institution of Mechanical ENGINEERS,

THOMAS HAWKSLEY LECTURE, 1922.

Dr. T. E. STANTON, C.B.E., F.R.S., (Member of Council) will deliver the above Lecture on "Some Recent Researches on Lubrication" at the Institution, Storey's Gate, Westminster, on FRIDAY, 1st DECEMBER, 1922, at Six p.m.
Visitors are Invited.
The Lecture will be repeated in Manchester, 7th December; Leeds, 8th December; and Birmingham, 13th December. W 888

Iron and Steel Institute.

28, Victoria Street, London, S.W. 1.

ANDREW CARNEGIE RESEARCH FUND

The Council of the Iron and Steel Institute is prepared to receive Applications for Grants in aid of Research Work on the Metallurgy of Iron and Steel.
The number of grants in any one year is limited to 5 or 6. The Council is not pledged to accept any particular application for assistance, but will give preference to those proposals which appear to them to be of the most practical advantage to the iron and steel and allied industries.
Proposals should be submitted before the end of February, 1923, on a special form to be obtained from the SECRETARY of the Institute. W 889

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SWANSEA HARBOUR TRUST.

The Trustees invite

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DELIVERY of the following:—
About 105 tons of 80 lb. FLAT-BOTTOM RD SECTION RAILS.
About 85 cwt. Shallow FISHPLATES to match.
About 85 tons of 80 lb. BULL-HEAD SECTION RAILS.
About 67 cwt. Shallow FISHPLATES to match.
About 100 tons New Slightly Defective 80 lb. FLAT-BOTTOMED SECTION RAILS with FISH-PLATES to match.
4830 NEW CREOSOTED SLEEPERS, 9 ft. by 10 in. by 5 in.
About 42 tons CAST IRON RAILWAY CHAIRS, approximately 44½ lb. each.
Ten STOP BLOCKS complete.
Further particulars may be obtained of the Trustees' Engineer, Mr A. O. SCHENK, M.I.C.E., Harbour Offices, Swansea.
Tenders, sealed and marked "Railway Material," to be delivered to the undersigned on or before 4th December, 1922.
The Trustees do not bind themselves to accept the lowest or any Tender.

TALFOURD STRICK, Clerk.

Harbour Offices, Swansea.
November 15th, 1922. W 880

SOUTH STAFFORDSHIRE WATERWORKS COMPANY.

SANDFIELDS PUMPING STATION, LICHFIELD.

CONTRACT No. 1.
The Chairman and Directors invite

Tenders from Engineering

Firms experienced in the Design, Construction and Erection of High Class Pumping Engines and Marine Engine Work for SUPPLYING and ERECTING DIESEL or STEAM ENGINES with ELECTRIC GENERATORS, FORCE PUMPS and WELL PUMPS, to be erected in the existing Engine House at their Sandfields Pumping Station, Lichfield.
The plant to be capable of pumping 4,000,000 gallons per 24 hours continuously against a total head of 440 feet, including friction.
Copies of General Conditions, Specification, and Plans may be obtained from the undersigned.
The lowest or any Tender will not necessarily be accepted.
FRED. J. DIXON, M.Inst.C.E., M.I.Mech.E., Engineer.
18th November, 1922,
26A, Paradise Street, Birmingham. W 866

SOUTH STAFFORDSHIRE WATERWORKS COMPANY.

SANDFIELDS PUMPING STATION, LICHFIELD.
HANCH RESERVOIR AND TUNNEL WATER.
CHEMICAL TREATMENT AND FILTRATION INSTALLATION.

CONTRACT No. 2.
The Chairman and Directors invite

Tenders from Manufacturers

experienced in the Design, Construction and Erection of Rapid Gravity or Pressure Filters, for the purpose of treating and filtering water at the Sandfields Pumping Station.
The Plant to be capable of dealing with a maximum supply of 4,000,000 gallons per 24 hours continuously.
Copies of General Conditions, Specification, and Plans may be obtained from the undersigned.
The lowest or any Tender will not necessarily be accepted.
FRED. J. DIXON, M.Inst.C.E., M.I.Mech.E., Engineer.
18th November, 1922.
26A, Paradise Street, Birmingham. W 872

H.E.H. THE NIZAM'S GUARANTEED STATE RAILWAYS COMPANY LIMITED.

The Board of Directors of H.E.H. the Nizam's Guaranteed State Railways Company Limited are prepared to receive

Tenders for the Supply of

the under-mentioned Girder Bridges:—
25 SPANS, 60 feet clear deck.
For each copy of the Specification a fee of Ten Shillings will be charged, which is not returnable. Tenders, enclosed in sealed envelopes addressed to the Chairman and Directors and endorsed "Tender for Bridgework," must be delivered at the Company's Offices not later than Twelve Noon on 5th December, 1922. The Directors do not bind themselves to accept the lowest or any Tender, and reserve the right to divide the Order.

By Order of the Board,
F. ADAMS, Secretary.

Winchester House, 80, Old Broad Street, E.C. 2.
20th October, 1922. W 806

THE SOUTH INDIAN RAILWAY COMPANY, LIMITED,
are prepared to receive

Tenders for the Supply of:—

STEELWORK for Paint and Electrical Shop (Trichinopoly Workshops Scheme.)
Specifications and Forms of Tender will be available at the Company's Office, 91, Petty France, Westminster, S.W. 1.
Tenders addressed to the Chairman and Directors of the South Indian Railway Company, Limited, marked:—"Tender for Steelwork for Paint and Electrical Shop," must be left with the undersigned not later than Twelve noon on Friday, the 15th December, 1922.
The Directors do not bind themselves to accept the lowest or any Tender.
A charge, *which will not be returned*, will be made of £1 for each copy of the Specification.
Copies of the Drawings may be obtained at the offices of Messrs. ROBERT WHITE & PARTNERS, Consulting Engineers to the Company, 3, Victoria Street, Westminster, S.W. 1.
A. MUIRHEAD, Managing Director.
91, Petty France, S.W. 1.
23rd November, 1922. W 910

THE BENGAL AND NORTH WESTERN RAILWAY CO., LTD.

The Directors are prepared to receive

Tenders for the Supply of—

(a) 3674 Four-Wheeled C.G. Wagons (complete) and 10 Bogie Timber Trucks (complete) except Wheels and Axles,
(b) 1454 Pairs of Wheels and Axles,
(c) Material for 240 Four wheeled C.G. Wagons,
(d) Buffers and Parts for Construction of 250 C.G. Wagons,
(e) 1000 Laminated Springs,
(f) 1000 Volute Springs,
(g) 1000 Axle Boxes,

as per specifications to be seen at the Company's Offices.
Tenders, addressed to the undersigned, and marked "Tender for Complete Wagons," or as the case may be, are to be lodged not later than Noon on Tuesday, the 19th day of December, 1922.
For specification (a) and (b) a fee of £1 and (c) to (g) 10s. each will be charged, which cannot, under any circumstances, be returned.
The Directors do not bind themselves to accept the lowest or any Tender.

By Order of the Board,
R. A. NEVILLE, Managing Director.

207, Gresham House, Old Broad Street, London, E.C. 2.
30th November, 1922. W 887

BOMBAY, BARODA & CENTRAL INDIA RAILWAY COMPANY.

The Directors are prepared to receive up to Noon on Wednesday, 13th December,

Tenders for the Supply of—

1. WHEELS & AXLES.
2. CAST STEEL BUFFER CASES.

Tenders must be made on forms, copies of which, with specification can be obtained at these offices on payment of 20s. each (which will not be returned).
The Directors do not bind themselves to accept the lowest or any tender.

S. G. S. YOUNG, Secretary.

Offices: The White Mansion, 91, Petty France, Westminster, S.W. 1.
November 30th, 1922. W 891

EAST INDIAN RAILWAY.

The Directors are prepared to receive up to Eleven o'clock a.m. on Wednesday, the 6th December, proximo,

Tenders for the Supply of:—

(1) METALS (Ingots of Copper, Tin and Zinc, and Lead Pig).
(2) STEEL TYRES for Carriages and Wagons.
(3) WHEELS AND AXLES and RETAINING RINGS.

Copies of the Specifications can be obtained at the Company's Offices on payment of £1 1s. each. This fee will not be returned.

G. H. LILLIE, Secretary.

73-76, King William Street, London, E.C. 4.
22nd November, 1922. W 911

COUNTY OF LONDON ELECTRIC SUPPLY COMPANY, LIMITED.

BARKING POWER STATION.

The County of London Electric Supply Company, Limited, are open to receive

Tenders for the Supply and

ERECTION of WATER TUBE BOILERS for their Barking Power Station. Specifications may be obtained by boiler manufacturers from the offices of the Company on application to the undersigned on or after 24th November, 1922, and on payment of a fee of Five Guineas for the first copy and Two Guineas for every subsequent copy. Sealed Tenders, marked "Tender for Water Tube Boilers for Barking Power Station," are to be addressed to the Chairman and Managing Director and lodged at the registered office of the Company by Noon on 19th December, 1922. Sums paid for any number of copies up to three will be refunded on receipt of a *bona fide* Tender.
The Company do not bind themselves to accept the lowest or any Tender.

F. C. MCQUOWN, Manager and Secretary,
The County of London Electric Supply Co., Ltd.,
Moorgate Court, Moorgate Place, E.C. W 864

THE BURMA RAILWAYS COMPANY, LIMITED.

The Board of Directors of the Burma Railways Company, Limited, are prepared to receive

Tenders for the Supply of:—

A. GIRDER BRIDGES (spans of 10 ft., 20 ft., 40 ft., 60 ft., and 100 ft.).
B. SPRING STEEL (tons 96/6).
C. WOOD SCREWS, NAILS, etc.

Fees for the Specifications, which are not returnable, will be charged as follows:—

For each copy of Specification	A	20s.
" " " "	B	10s.
" " " "	C	5s.

Tenders, enclosed in sealed envelopes endorsed "Tender for Girder Bridges," or as the case may be, must be delivered at the Company's Offices not later than 12 noon on the following dates:—
A, Wednesday, 6th December, 1922.
B and C, Friday, 1st December, 1922.
The Directors do not bind themselves to accept any or the lowest Tenders, and reserve the right to divide the orders.
Shipment of the Girder Bridges is not required before the middle of March, 1923.
The greater part of the Spring Steel and Wood Screws, Nails, etc., is urgent.

By Order of the Board,
F. C. FRANKS, Secretary.

199, Gresham House, Old Broad Street, London, E.C. 2.
23rd November, 1922. W 909

THE GREAT INDIAN PENINSULA RAILWAY COMPANY.

The Directors are prepared to receive

Tenders for the Supply of the

following STORES, namely:—

		Fee for Specification.
No. 1.	Whitewash Brushes... ...	5/-
No. 2.	Mantles for Lamps	1/6
No. 3.	Spare parts for Carriages and Wagons (Buffers, etc.) ...	£1
No. 4.	Sheffield Tools	10/-
No. 5.	Rolled Steel Disc or Spoke Wheels and Axles ...	£1
No. 6.	Lamps and Fittings... ...	10/-
No. 7.	Stationery, etc.	10/-
No. 8.	Helical and Volute Springs	10/-
No. 9.	Pig Iron	10/-

Specifications and Forms of Tender may be obtained at this office on payment of the fee for the Specification, which payment will not be returned.
The fee should accompany any application by post. Cheques and Postal Orders should be crossed and made payable to the Great Indian Peninsula Railway Company.
Tenders must be delivered in separate envelopes, sealed and addressed to the undersigned, marked "Tender for Whitewash Brushes" or as the case may be, not later than Eleven o'clock a.m., on Tuesday, the 5th December, 1922.
The Directors do not bind themselves to accept the lowest or any Tender.

R. H. WALPOLE, Secretary.

Company's Offices, 48, Cepthall Avenue, E.C. 2, London, 22nd November, 1922. W 912

THE HIGH COMMISSIONER FOR INDIA is prepared to receive

Tenders for the Supply

of:—
GIRDER BRIDGES, 100 ft. span.
Forms of Tender may be obtained from the Director-General, India Store Department, Branch No. 16, Belvedere Road, Lambeth, S.E. 1, and Tenders are to be delivered at that Office not later than Two o'clock p.m. on Thursday, the 14th December, 1922.

T. RYAN, Director-General. W 878

APPOINTMENTS OPEN.

ROYAL NAVAL ENGINEERING COLLEGE KEYHAM (PLYMOUTH).

Applications are Invited

for the following POSTS:—
1. SENIOR LECTURER IN ELECTRICAL ENGINEERING, who, under the organising Naval Engineer Officer will, in addition to giving lectures, advise on equipment of laboratories and workshops, and assist in arranging the studies and practice in Electricity and Electrical Engineering. Good University degree and practical experience essential. Salary £650–£1,000; by £25 annually, inclusive of bonus, with Superannuation benefits under the Federated Universities Superannuation Scheme.
2. LECTURER in ENGINEERING SUBJECTS, particularly Applied Mechanics, Mechanism, Heat, and Steam. Candidates should possess a good Honour Degree, and have had experience in Engineering practice and teaching. Salary £400–£600 by £25 annually, inclusive of bonus, with Superannuation benefits as above.
3. DEMONSTRATOR in Engineering Laboratory, particularly in connection with the mechanical testing of metals. Some experience of elementary Electrical and Chemical laboratory work also desirable. Salary £250–350 by £20 annually, inclusive of bonus, with Superannuation benefits as above.
Applicants should state age, qualifications, and furnish full particulars of similar appointments held, and forward copies of testimonials and references not later than November 27th, to the

SECRETARY OF THE ADMIRALTY (C.E. Branch), Whitehall, S.W. 1. W 817

SOUTHPORT BIRKDALE AND WEST LANCASHIRE WATER BOARD.

APPOINTMENT OF WATERWORKS MANAGER AND ENGINEER.

The Board Invite

Applications for the Appoint-

ment of WATERWORKS MANAGER and ENGINEER.
Applicants must be duly qualified Civil Engineers, not more than 45 years of age, and must have had experience in the management of a Waterworks Undertaking supplied by Pumping from Deep Wells.
The salary will be £750 per annum inclusive.
Particulars of the qualifications, duties and conditions of appointment can be obtained from the undersigned.
Applications must be made on the official form and must reach me before 12 Noon on the eleventh day of December, 1922.
Canvassing either directly or indirectly will be a disqualification.

J. ERNEST JARRATT, Clerk to the Board.

Town Hall, Southport, 18th November, 1922. W 871

G. R.

MINISTRY OF TRANSPORT.
ROADS DEPARTMENT.

Applications are Invited for

the following APPOINTMENTS in connection with road construction schemes in the vicinity of London:—
TEMPORARY ENGINEER, salary £600 per annum inclusive.
TEMPORARY ASSISTANT ENGINEERS, salary £350 per annum inclusive.
Candidates should be Associate Members of the Institution of Civil Engineers, or should hold the testamur of the Municipal and County Engineers' Institution, or some equivalent professional qualification. Practical experience in modern road and bridge construction is essential. Preference will be given to candidates under 40 years of age, and only men who have served in His Majesty's Forces will be considered.
Forms upon which application must be made can be obtained from the ESTABLISHMENT OFFICER, Ministry of Transport, 6, Whitehall Gardens, S.W. 1. The completed forms must reach the Ministry of Transport not later than Monday, the 4th December, 1922. W 919

Wanted, Engineer, aged

about 25, unmarried, for pushing sale of Oil Engines in India. Essential applicants should have expert and up-to-date knowledge thereof, Public School training, and of good personal appearance.—Reply, giving fullest details of experience, age and salary required, Z. F. 304, c/o DEACONS, Leadenhall Street, London. W 921

Wanted, Metallurgist for

large Industrial Plant. Must be conversant with the latest methods of heat treatment, tempering and case hardening of steel. Applicants should state qualifications, experience, past and present employers, which will be treated confidentially.—METALLURGIST, WILLIAM PORTEOUS & Co., Advertising Agents, Glasgow. W 907

The Technical Director of

THE CHATWOOD SAFE CO., LTD., Bankers Engineers, Bolton, REQUIRES an ASSISTANT as Works Engineer who has had actual experience in dealing with plant methods of manufacture and rate fixing in a well organised engineering works.
Applications will receive confidential consideration and must be addressed to the MANAGING DIRECTOR. W 883

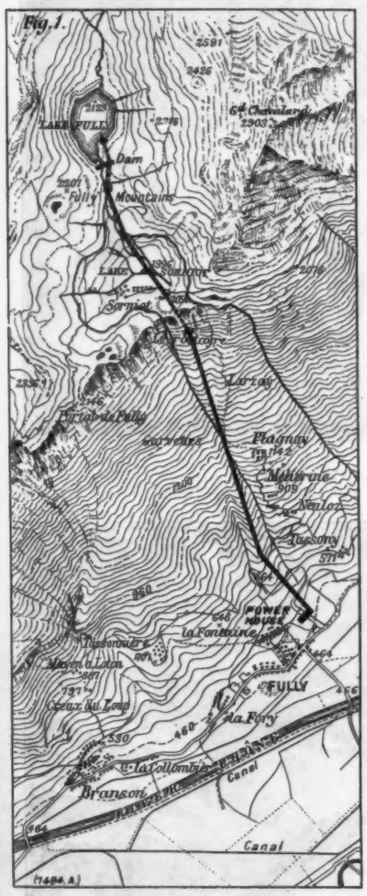
THE FULLY HYDRO-ELECTRIC POWER STATION, SWITZERLAND.

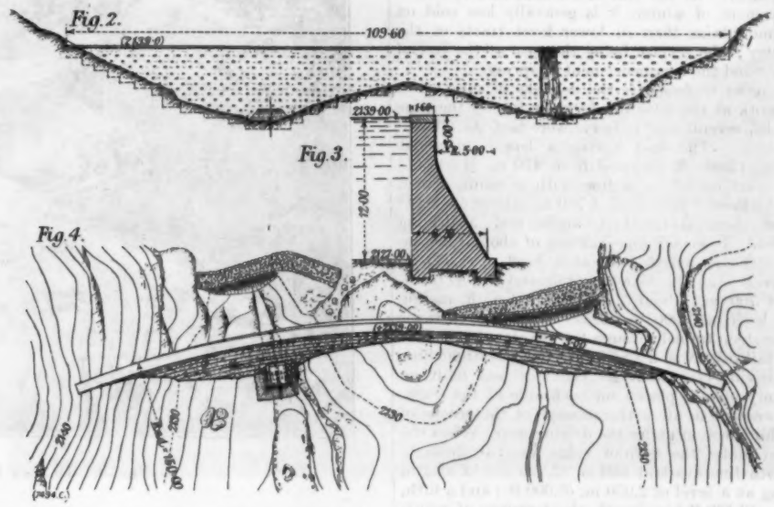
The working of hydro-electric power stations in the Alps, which are operated by water courses fed by glaciers is, as is well understood, entirely dependent upon the quantity of water available; low water occurs in the winter, and the periods of high water are in the summer months, when the glaciers are melting. At low water the flow is generally much below the average, and when the equipment of the stations does not include heat engines as a standby, power may fall to very low limits during the winter. A means for overcoming this difficulty is the provision of water reservoirs at a high level, and one of the most interesting examples of a power station under such conditions is the one at Fully, Valais, Switzerland, which works under a head of 1,650 m. (5,415 ft.), this being probably by far the highest working head ever utilised. We gave preliminary particulars of this installation in a former issue.* Its building from first to last was surrounded by many difficult problems, and the detailed description which we now propose to give will be found of interest. In the first place we may state that the work was carried out from 1912 to 1914 for the Société d'Electro-Chimie, by Mr. A. Boucher, the Swiss hydraulic engineer, who, during the last twenty years has designed and built other power stations working under a high head, such as those of Tanay Lake, Switzerland, and Orlu, in the Pyrenees, the head of each being about 930 m. (3,050 ft.). The Société d'Electro-Chimie entrusted Mr. Boucher, in 1909, with the Martigny, Valais, power station, situated on the river Drance. This latter was built for a maximum of 16,000 h.p., its capacity falling to as low as 5,000 h.p. in extreme low water periods, *i.e.*, at the end of the winter months; the working head is 175 m. (574 ft.). The Fully power station has been built to be complementary to the one at Martigny; it has been in regular operation since 1915, and has met its purpose admirably.

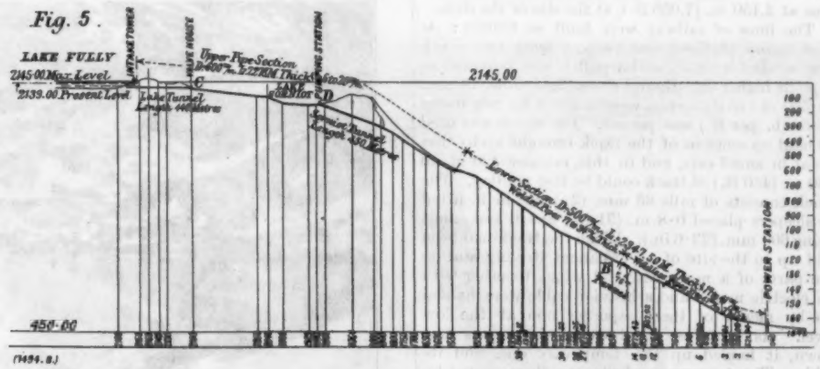
The lake of Fully is on the south-east slope of the Dents de Morcles, at an altitude of 2,130 m. (about 7,000 ft.). A smaller lake, the Sorniot Lake, is at a slightly lower level, 1,990 m. (6,530 ft.); its water is also utilised, as will be shown further on. Both lakes, together with the dam built to increase the capacity of the higher one and the pipe-line, are shown in Figs. 1 to 5. The floor level of the engine room at the power station is at an elevation of 500 m. (1,640 ft.). A crest of rock formation, the Col de Sorniot, stands at an altitude of about 2,060 m. (6,625 ft.); the Sorniot Lake is directly in the rear of this, and the pipe-line runs in a tunnel cut under this rock formation (Fig. 5). The dam in course of construction and completed is shown in Figs. 6 and 7, on page 636. The power derived from the Fully Lake, under the head of 1,650 m. (5,415 ft.), may be calculated as follows: One litre of water under this head develops 16·5 h.p. on the turbine shaft, reckoning upon a turbine efficiency of 75 per cent., equal to 12 kw. at the terminals of the dynamos. A constant flow of 1 litre per second during one year, or a total of 31,536 cu. m., would, therefore, correspond to about 100,000 kw.-hours. Each cubic metre (220 gallons) of water in the lake thus corresponds to an available power of 3·15 kw.-hours. The velocity of the water on its issue from the jet at the turbine is about 165 m. (540 ft.) per second, equal to nearly 600 km. (370 miles) per hour, and a nozzle having a diameter of only 38 mm. (1·5 in.) suffices to yield, under a net head of 1,600 m. (5,250 ft.) as much as 3,000 h.p. The water storage is at an altitude of 2,139 m. (about 7,000 ft.), the volume of water is almost 3,200,000 cub. m. (700,000,000 gallons), giving in round figures, a total of 10,000 000 kw.-hours.

One of the main difficulties in the work was due to the great altitude at which part of it had to be carried out, and to the very limited duration of the fine weather season. Fully Lake is free from ice at the end of June or in July only, and in July to September the work had occasionally to be stopped owing to snowstorms. In winter the work at the lake was completely suspended, the installations and sheds being covered by snow to the depth of several yards. Until the steep tunnel under the Sorniot ridge was cut the only means of access to the works at the lake was a small footpath, and everything had to be carried up by labourers. It took about 5 hours to reach the lake from the site of the power station. The labourers were paid for this at the rate of 0·10 francs per kg. (about ½d. per pound) for pieces weighing up to 20 kg. (44 lb.), and proportionately more for all heavier pieces. All the mechanical appliances for driving the tunnel, for work at the lake and for sinking a shaft, compressors, electrical machinery, &c., were carried up by men; the heaviest piece weighed 250 kg. (550 lb.).

As soon as the work was decided upon, the construction of rope railways giving access to the lake was commenced, together with the laying of a power transmission line of aluminium and a telephone line. In order to save time, the cutting of the intake tunnel, the sinking of the intake shaft at Fully lake, and the cutting of the tunnel under the Sorniot ridge were commenced simultaneously by hand; these works were carried on afterwards by mechanical means. Huts were also built for the men at an altitude of 2,100 m. (about 7,000 ft.). The work at the tunnels was put in hand on August 1, 1912. On October 26, of the same year, heavy falls of snow shut the men in the workings; they were seized with panic and refused to continue the operations. An avalanche carried away four men who, fortunately, were rescued and were found not to have suffered to any great extent. Work could not be resumed until the middle of May, 1913.







* See ENGINEERING, vol. cx, page 823.

The steep tunnel under the Sorniot ridge was cut through at the end of September, 1913; this facilitated access to the lake, and enabled ten specially well-trained men to work at the lake until December 20, 1913. The work at the intake was taken in hand afresh at the end of May, 1914, and on October 11, the thickness of rock which separated the intake gallery from the lake was blown out by a mine. At the end of October, 1914, therefore, two years and three months only after the work was first started, the hydro-electric sets at the power station could be tested for current production.

It is interesting, in connection with work carried out at a high altitude in Switzerland to remark that the seasons vary greatly. The weather in March is colder than in December, and that in April does not compare favourably with the weather in November. At the end of autumn and the commencement of winter, it is generally less cold on the mountains than in lower level tracts of the country; the reverse being the case at the end of winter and the commencement of spring.

In order to facilitate the delivery of supplies to the work at the lake and for carrying up the pipe lengths, several rope railways were laid, as alluded to above. The first having a length of about 900 m. (2,960 ft.) started from 470 m. (1,545 ft.) level and ended in a line with a point named "Le Château" at a level of 760 m. (about 2,500 ft.) where there is the first angle and a driving station. A second rope railway of about 1,650 m. (5,415 ft.) in length ends at a level of 1,550 m. (5,085 ft.) at les Garettes, followed by a third, about 700 m. (about 2,300 ft.) in length, ending at a level of 1,900 m. (6,235 ft.) at the entrance to the steep tunnel through the Sorniot ridge. The rope railways Nos. 2 and 3 being in a straight line, the driving station at les Garettes was built on masonry pillars, placed on each side of the track, high enough to allow the passage of the trucks of the third section under the driving gear. When the tunnel under the Sorniot ridge was cut through, a fourth line was laid 850 m. (2,790 ft.) in length, ending at a level of 2,050 m. (6,600 ft.) and a fifth, 650 m. (2,130 ft.) in length, the terminus of which was at 2,150 m. (7,055 ft.), at the site of the dam.

The lines of railway were built as follows: As soon as one platform was ready, a temporary winch was erected upon it, and a pulley was provided at a point higher up. Round this a light cable 15 mm. (0·590 in.) in diameter, weighing 0·8 kg. per metre (0·54 lb. per ft.) was passed. The winch was used to haul up sections of the track brought up to that point in small cars, and in this manner 120 m. to 150 m. (450 ft.) of track could be laid per day. The track consists of rails 65 mm. (2·5 in.) high, fitted to sleepers placed 0·8 m. (31 in.) apart, the gauge being 600 mm. (23·6 in.). When the track had been laid up to the site of a permanent driving station the parts of a more powerful winch together with its electric motor and a heavier cable were hauled up by means of the temporary one at the low level. As soon as the heavier winch was put down, it hauled up the temporary one, and its cable. The temporary winch was then erected by the side of the heavier one and was used for the second and other lengths of track in the same way as for the first.

It having been decided that the weight of a pipe length should not exceed a maximum of 4,000 kg. (8,800 lb.), the three lower winches were calculated for a gross load of 4,500 kg. (9,900 lb.), the pull on the cable being 3,600 kg. (7,920 lb.). The maximum gradient of the track is close to the top part of the second length from Château to Les Garettes where it is 105 per thousand (about 1 in 10.) The winch and its motor are mounted on a common bed-plate built up of steel sections. The cast-iron drum, 1200 mm. (47·25 in.) in diameter, and 1200 mm. in length is cast with a flange on either side; a cast-steel spur wheel is bolted to one of the flanges, the other being fitted with the brake drum on which acts a safety band brake. A hand brake and a speed regulator are provided; the latter comes into play and acts upon the safety brake when the speed of the winch exceeds a given limit. The safety brake can also be worked by the man in charge, operating a pedal. The drive is by cast-steel spur wheel gearing; the motor which has a speed of 720 revolutions is fitted with a switch for reversing. According to the load the winch has a speed of 0·30 m. or 0·75 m. (11·8 in. or 29·5 in.) per second. The cable has a factor of safety of 5. It consists of 114 wires of 1·25 mm. (0·050 in.) in diameter, and weighs 1·25 kg. per metre (1·8 lb. per foot). Two small trucks illustrated in Figs. 8 to 10, fitted with bolsters, and connected together by a chain were used for hauling up the pipes, which weighed 4,000 kg. (8,800 lb.) maximum, and were in lengths of from 6 m. to 12 m. (19 ft. 8 in. to 39 ft. 4 in.) according to the thickness. Each truck had a capacity of 2,000 kg. and curves 6 m. (19 ft. 8in.) in radius could be negotiated. The cast-steel wheels were 300 mm. (11·8 in.) in diameter and 100 mm. (3·94 in.) in width at the tread. A shunting loop was provided at each driving station and the crossing of loaded trucks travelling upwards by empty ones on the downward journey, took only from 2 min. to 3 min. The two winches connecting the power station to the Garettes have been left standing in order to facilitate access to the lake. Views of the rope railway are shown in Figs. 11 to 13 on the opposite page.

Fig. 6. Dam in Course of Construction.

Fig. 7. The Dam Completed.

The intake at the upper Fully Lake is shown in Fig. 14, on page 638. The scheme provided that the intake gallery, about 500 m. (1,640 ft.) in length, should be carried to approximately the 2,100 m. (6,890 ft.) level, that is to say, to a point where, it was surmised, there would remain a rock thickness of 2 m. to 3 m. (6 ft. to 9 ft.) only, which would have been blown up by a mine. A shaft (see Fig. 14) was sunk close to the lake side. In view of the geological

formation and on the basis of soundings carried out it was anticipated that the intake gallery could be driven in solid rock over a length of 65 m. (213 ft.) from the shaft. But when 48 m. (157 ft.) had been driven, a bed of clay was met which greatly complicated the work. In these circumstances it would have been dangerous to continue driving the intake gallery without decreasing the height of water above it. One means of meeting the situation would have been the emptying of the lake, but owing to local conditions this would only have been possible gradually and by trenches and shafts. Moreover, the contingencies would not have been eliminated entirely by this means, and the measure would have delayed starting up the power station for one or two years. These considerations led to the adoption of the following solution. A masonry wall was built in the intake gallery, and at about 15 m. (50 ft.) from this end a second shaft was driven upwards closer to the lake at a point where the rock formation was still visible. When there remained a thickness of rock of from 2 m. to 3 m. (6 ft. to 10 ft.) only, this was blasted by a mine exploded from the top of this second shaft. Should it be found necessary later, the level of the intake could be lowered; in this connection, however, it may be remarked that during the seven years the power station has been running, the lowest water level of the lake has never been below 2,125 m. (about 7,000 ft.), and so far it has therefore been impossible to unwater the intake gallery and to ascertain the effect of the explosion here referred to.

The intake has been designed for a discharge of 800 litres (178 gallons) per second, corresponding to 12,000 h.p. Since it was not found advisable to empty the lake so as not to waste the water accumulated during a season, all the component parts and fittings of the intake shaft were erected before the explosion, establishing communication with the lake, occurred; means were taken to prevent all obstruction of the pipe inlet strainer by debris, and all the parts of the intake mechanism being under water and difficult of access, have been made simple in design and of durable material.

The intake valve and strainer are illustrated in Figs. 15 to 23, page 638. The actual intake valve is shown at E; it is of cast steel, and has four guide ribs F formed of steel plates riveted on, as shown in Fig. 15, the arrangement being strong and rigid. The valve bears against a seat G (also of cast steel) 400 mm. (15·7 in.) inside diameter embedded in the masonry. It will be noticed that this internal diameter, 400 mm., is considerably less than that of the pipe line in its upper part, which is 600 mm. (23·6 in.). This gives the water through the valve and at maximum flow a somewhat high velocity, of 6·3 m. (20 ft. 8 in.) per second. This is quite a permissible velocity; it results in a loss of pressure head of about 2 m. (6 ft. 6 in.) only, a low figure compared with the available head. The main valve is provided with a small filling valve H of cast steel. The working on opening is as follows: The valve being closed and the pipe line empty, by means of a winch a pull is exerted on the suspension ring J, connected to the rod K, to which is attached at its lower end the small valve H and the washer L; the small valve is raised until the washer L butts against the large valve. At that moment the filling orifice, 150 mm. (5·9 in.) inside diameter is fully open and the filling of the conduit takes place slowly. When the lake is at its highest level and the small valve is fully opened out, the pipe

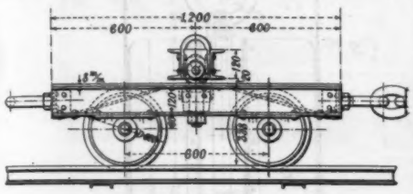


Fig. 8.

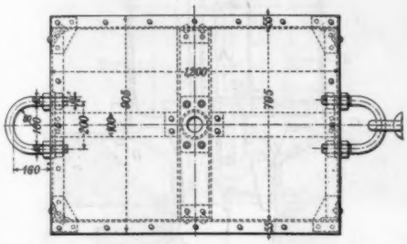


Fig. 9.

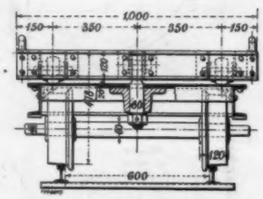


Fig. 10.

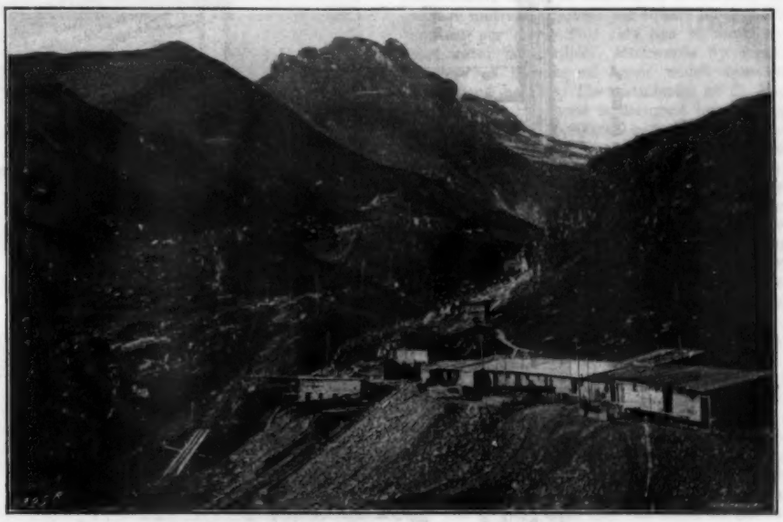


FIG. 11. VALVE HOUSES AND PLANT AT THE LAKE DURING CONSTRUCTION.

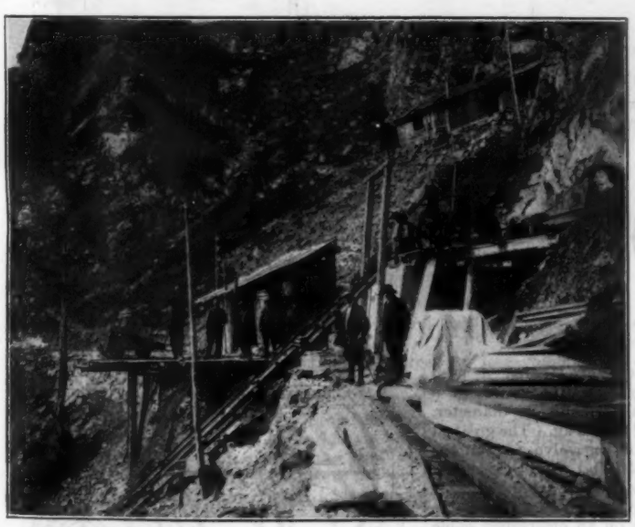
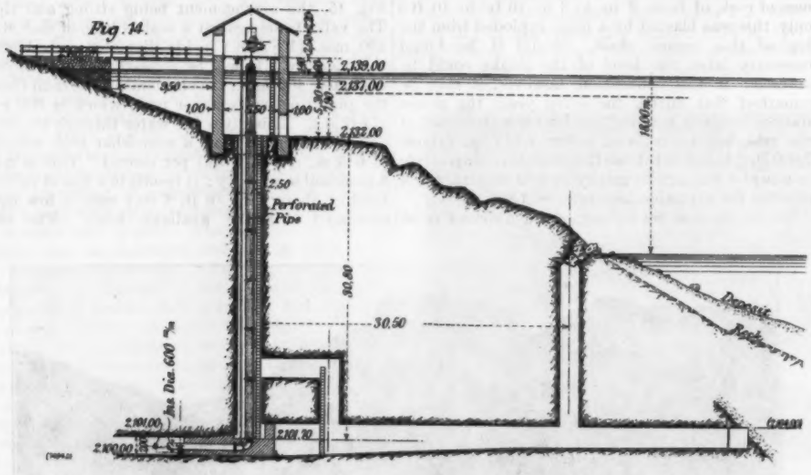


FIG. 12. LOWER END OF SORNIOT TUNNEL.

FIG. 13. CONSTRUCTION RAILWAY.

INTAKE WORKS OF THE FULLY HYDRO-ELECTRIC POWER STATION.



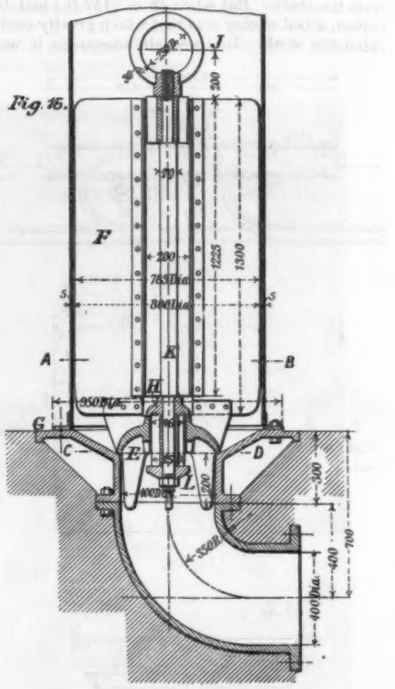


Fig. 24.

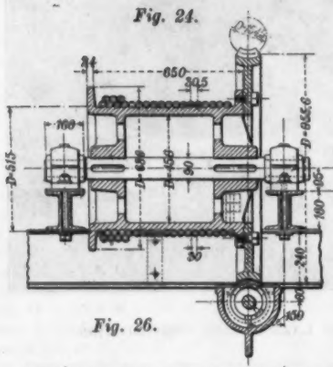


Fig. 25.

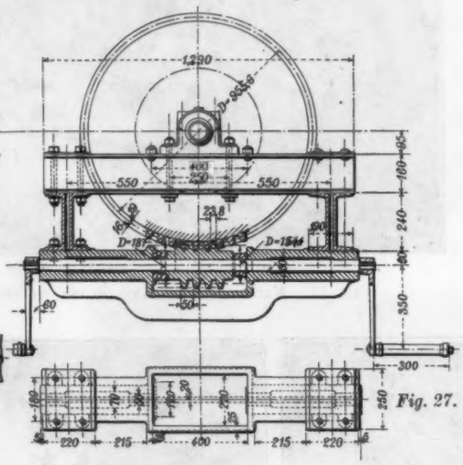


Fig. 26.

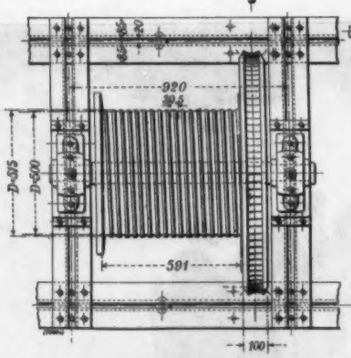


Fig. 27.

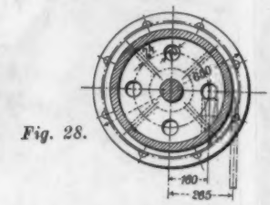
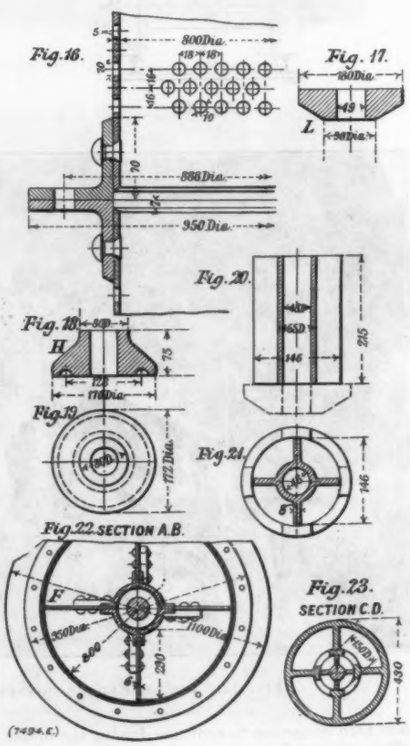


Fig. 28.



line fills in about 1 hour, the air escaping through a vent. As soon as the pipe line is completely filled the load acting upon the valve E is balanced, and this valve E can then be opened. This can be done either to an extent strictly necessary for the passage of the maximum output, *i.e.*, a lift of from 10 cm. to 15 cm. (3·9 in. to 5·9 in.), or the whole valve E can be completely raised for inspection, this being the procedure generally followed. On the other hand, the valve E can be closed at any time, even if by the result of an accident the pipe line were empty or were emptying itself; the winch has been specially designed to effect this, as will be pointed out further on. In case of fracture of the pipe line between the intake and the automatic valve at the delivery end, the intake could be rapidly closed, thus preventing the emptying of the lake. We shall deal further on with this automatic valve. The relatively smaller internal diameter, 400 mm., of the intake valve would have the advantage of limiting to some extent the volume of water which would escape in case of an accident until the intake was closed. The fact that the main valve, together with the small filling valve, can be lifted out allows of thorough inspection and of repairs, if need be. The valve is connected to the winch by a flexible steel cable 30 mm. (1·2 in.) in diameter, having a tensile strength of 21,000 kg. The greatest pull that can be exerted on the valve, *i.e.*, on the cable, is 5,250 kg. (11,550 lb.). The cable has therefore a factor of safety of 4. Should the cable break, a most improbable eventuality, the valve could be lifted by a hook on an emergency cable engaging the ring J.

The winch for operating the inlet valve, illustrated in Figs. 24 to 28, is a very simple apparatus, consisting of a drum round which is wound the cable. The drum is 515 mm. (20·2 in.) in diameter and 590 mm. (23·2 in.) in width, and carries a worm wheel 955·6 mm. (37·6 in.) in diameter on the pitch line, and having 60 teeth. The wheel is operated by a worm, and two cranks, 350 mm. (13·7 in.) in radius, are keyed on the worm spindle. The maximum pull on the valve when closed, the lake being at its highest level and the pipe line empty, is 5,250 kg., as above stated. Under these conditions to raise the valve the effort, to be applied on the cranks, would be of about 150 kg. This makes it impossible with the worm adopted, to open the valve under these circumstances. On the other hand, the lowering of the valve is easy, and towards the end of the closing action the 5,250 kg. load comes into play, the work at the cranks being almost nil. The gear requires no brakes of any kind, no pawl, nor other safety device as used with spur wheel winches. The whole arrangement is carried on two joists, 240 mm. (9·4 in.) high, which rest on the wall of the well shaft. A footbridge

THE PARIS WATER SUPPLY.

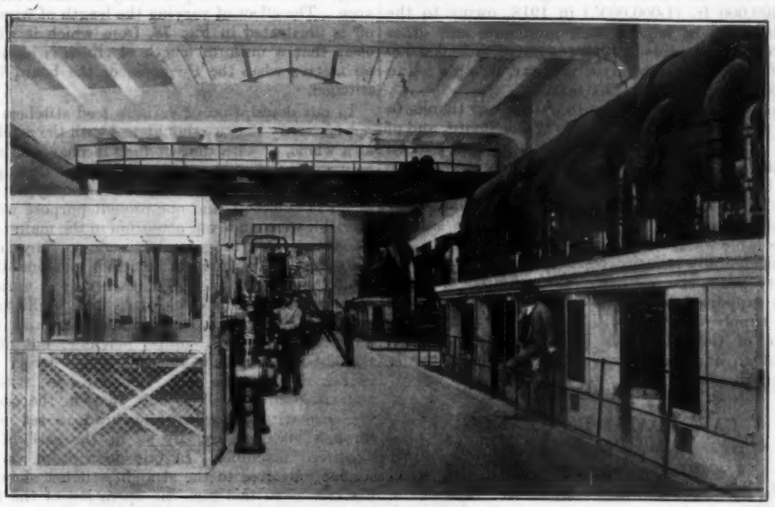


FIG. 13. THE OZONISING PLANT.

FIG. 14. DESATURATING CHAMBERS.

establishes a connection with the lake side and gives access to the winch.

The strainer, Fig. 16, is a built-up vertical pipe having holes of 10 mm. (0·393 in.). It is 35·5 m. (116 ft. 6 in.) in total height. The inside diameter is 800 mm. (31·5 in.). The water of the lake being very clean, there being no fear of dead leaves owing to the altitude, the choking up of the strainer is not to be feared. Advantage is taken of low water in the lake to free the strainer of any foreign matter which may have settled upon it.

Before the commencement of the work, peasants had built at the lake outlet a small dam, formed of loose stones and earth, the upper surface of which was at a level of 2,131 m. (about 7,000 ft.), the intention being to store a part of the water proceeding from the melting snow, and thus increase the amount available in summer for watering purposes. The dam comprised in the work for the power station here referred to was built below the small dam in question. It is shown in Figs. 1 to 4 and in the views Fig. 6 and 7. The volume of water now available is, as above stated, 3,200,000 cub. m. The highest impounding level allowed by the concession is 2,145 m. (over 7,000 ft.). The dam has a total height of 14 m. (46 ft.), including the foundations. The two faces consist of rubble stone masonry; the stone was quarried close to the site. The central part of the dam was built up of concrete and large plums, a rapid method, and one which obviated the use of shuttering which is always costly. The foundations are on the rock. The "down stream" side of the dam is not smooth; the rubble stones have been left protruding in order to facilitate the task of increasing the thickness of the dam, when later its height is increased. The dam has at the crest a length of 110 m. (360 ft.); when it was first put under pressure, leakage occurred at parts due to shrinkage in the masonry. The cracks filled up naturally for the most part, and the dam was rendered perfectly tight afterwards by grouting with cement. The mixture consisted of a sack (45 litres) of slow setting cement with 30 litres to 35 litres of water. The dam is provided with a spillway and two bottom valves 300 mm. (11·8 in.) in diameter.

(To be continued.)

TRAFFIC AT THE PORT OF COPENHAGEN.—The *Danish Foreign Office Journal* states that, according to official statistics, traffic at the port of Copenhagen in the three months April to June of this year the arrivals numbered 3,513 ships aggregating 922,296 net registered tons, while the sailings amounted to 3,530 ships aggregating 930,900 net registered tons.

THE PARIS WATER SUPPLY.

(Concluded from page 576.)

AFTER filtration in the beds, described in our last article, the water is subjected to treatment in an ozonising plant. In connection with the filtration plant, though fairly clear from the description given, it may be stated that the initials R. W., C. W. and P. W., in Figs. 6 to 11, page 575 *ante*, have the following meanings:—R. W., raw water; C. W., clarified water; P. W., potable water. The arrangement for ozonising the water consists of an ozonising plant, by the Compagnie Générale de l'Ozone, on the M. P. Otto process, put down close to the filter beds in 1912 (see Fig. 15, page 650). When water is purified by simple filtration, the rate of working must be limited to 2·400 cub. m. per square metre (50 gallons per square foot) of filtering surface per day. This rate can be doubled when the water is sterilised afterwards by some such process as the use of ozone which removes the pathogene bacilli. The installation at St. Maur for sterilisation by ozone is designed for dealing with 90,000 cub. m. (19,800,000 gallons) of water per day. Fig. 16, page 650, shows a general view of the interior of the sterilising plant, other views being given in Figs. 17 and 18, on page 650, and Fig. 13 annexed. Sterilisation is secured by causing the ozonated air to mix with the water which requires sterilisation. The operation takes place in a cylindrical vessel styled a self-contact column, in which the water and the ozonated air circulate from bottom to top. The water is forced by electrically-driven pumps, shown in Fig. 18, into an apparatus in which it passes through stone-ware pipes fitted inside and extending through its whole height. The pipes are provided with injectors which act as aspirators for the ozonated air. The two fluids, water and air, thus pass into the apparatus together and flow upwards forming eddies which divide up the air and insure as close contact as it is possible to obtain. The ozonated air is produced by two classes of apparatus, one on the Otto system and the other on the Siemens de Frise. In the first, the dielectrics by means of which the ozone is generated under the action of high pressure and high frequency current consist of parallel glass plates. In the second they are formed of concentric tubes. The air previously dried by freezing in a methyl chloride plant is drawn by injectors and circulates inside the dielectrics. A part of the oxygen is transformed into ozone, and the ozonised air flows from the dielectrics to the self-contact columns. The ozonising appliances have a tendency to become heated and are kept cool by a current of cold water. The alternating current for ozonisation arrives at the main switch-board at a pressure of 5,000 volts and 50 periods. The pressure is stepped down to 110 volts, and with this current is generated at 220 volts, 500 periods, by motor generator sets, shown in Fig. 17. Moreover, each battery of ozonising apparatus is connected to static transformers which raise the pressure to 9,000 volts in the case of those used in the Otto process and to 8,000 volts in that of the Siemens de Frise. There are five sets of apparatus of each system with which correspond ten sterilising columns. A view of one set is given in Fig. 13 annexed. On leaving these, the water flows in cascade in desaturating reservoirs in which it rids itself of the excess ozone; a view of this part of the plant is shown in Fig. 14. For sterilising by ozone the energy consumption is from 20 to 30 watt-hours per cubic metre of water (per 220 gallons).

The micro-organisms which may still exist in the filtered water can be destroyed by chlorination on the Javel system. The process consists in mixing with the water in a scientifically determined proportion a solution of hypochlorite of lime. At St. Maur the solution is placed in the central reservoir which collects the water from all the filter beds. The small excess of chlorine which may remain in the water after destruction of the organic matter is neutralised either by a solution of chlorhydrate or sulphate of ammonia or by a solution of hyposulphite. The water thus sterilised is then drawn off and delivered to the town supply by the pump sets above referred to. A chemist is constantly in charge of this process.

The St. Maur filtering installation has at the

present time a capacity of 120,000 cub. metres (26,400,000 gallons) of filtered water per 24 hours. During 1921, the average daily supply was 100,000 cub. m. (22,000,000 gallons).

Apart from the installations thus briefly described, there are others whose duty is both to raise the raw and the filtered water, and also raw river water to high levels to supply the districts of Paris which are at a higher elevation. These are the Ourcq works (having beam and horizontal steam engines); the Charonne works (horizontal steam engine, steam turbines driving centrifugal pumps, electrically driven pumps); the Montsouris works (horizontal engines and electrically driven pumps); the Gentilly (horizontal steam engines); the Ménilmontant (triple expansion steam engines); and the Montmartre (horizontal steam engines and electrically driven pumps). The latter and the Ménil montant plant are to be increased shortly to provide for higher lifts.

The reservoirs for the storage of potable water exclusively are those at St. Cloud, which takes water from the Avre, and at Montsouris, which takes water from the Vanne, the Loing and the Lunain. Others, as above stated, have compartments for potable and for raw water, such as that at Ménilmontant, which takes water from the Dhuis in its two upper compartments, and water from the Marne in the lower one, and those at Passy, Charonne, Belleville and Montmartre. Those which only take raw water are the Villejuif, Buttes-Chaumont and Gentilly reservoirs.

The potable water is constantly under the supervision, for insuring its wholesomeness, of a special department which inspects the catchment areas, and takes samples at the sources of supply, in the aqueducts, in the filtering installations and in the Paris mains. The samples of water are analysed for ascertaining their purity from the chemical and bacteriological standpoints. Causes which would make for eventual contamination are thoroughly gone into and attention is called to water of doubtful quality. Another department has charge of watching any epidemic which may occur in the vicinity of the catchment areas, and of taking every prophylactic measure to prevent any contamination of the underground water. Stations for sterilisation by means of hypochlorite of lime are installed on the various aqueducts and, as above stated, in the filtering plant. Owing to the sterilising process, the Paris filtered water is as pure as the water supplied to the town from springs, but the latter has, over the former, the advantage of remaining cooler in summer.

The delivery piping is put down at the expense of the consumers by the Paris Water Company. According to an agreement entered into with the Paris Municipality, on February 11, 1911, this company has under its control the water meters at the various buildings and dwellings, it collects the water rates on account of the municipality, without interfering in any way with the water service. The company is paid for this an annual percentage, the amount of which is quoted in the agreement. The cost of potable water at the present time is 0·65 fr. per cubic metre (about 6·5*d.* per 220 gallons). Raw water is sold according to a tariff, the average price is 0·30 fr. per cubic metre (about 3*d.* per 220 gallons).

The aqueducts have a total length of 480 k. (300 miles) excluding the Ourcq canal, the length of which is 107 k. (66 miles). The pumping plant has a total power of 15,000 h.p. The potable water reservoirs have a capacity of about 600,000 cub. m. (132,000,000 gallons) of potable water and 200,000 cub. m. (44,000,000 gallons) of raw water. The total length of mains for the two classes of water is 2,750 kilom. (1,710 miles), on which are 6,540 sluice valves. There are on the public thoroughfares 18,364 street and other hydrants. The daily consumption in 1919 amounted to 390,500 cub. m. (85,910,000 gallons) of potable water and 645,000 cub. m. (141,900,000 gallons) of raw river water, a total of 1,035,500 cub. m. (227,810,000 gallons), corresponding, for a population of 3,000,000, to a consumption of about 135 litres (about 30 gallons) per day of potable water, and 225 litres (about 50 gallons) of raw water per inhabitant. The service is carried on by a staff of 200, with 1,600 workmen. The capital involved may be reckoned at 420,000,000 fr. (16,000,000*l.*). Working and maintenance charges were, in 1913, 11,940,000 fr. (470,000*l.*), a figure which rose to 25,400,000 fr. (1,000,000*l.*) in 1918, owing to the higher cost of labour, fuel, lubricants and other material. Receipts in 1913 amounted to 29,000,000 fr. (1,100,000*l.*); owing to the war, receipts fell in 1918 to 24,300,000 fr. (960,000*l.*).

In conclusion, we desire to extend our thanks to the managing staff of the Paris Water Board, and of the St. Maur Waterworks for the greater portion of the information given in the foregoing; also to the Compagnie Générale de l'Ozone and its engineer, Dr. M. P. Otto, for the excellent views and particulars dealing with the most important subject of potable water sterilisation by ozone.

Incidentally it is interesting to note that about thirty years ago a scheme was enquired into and was supported by a number of civil engineers for the supply of Paris with water taken from the Lake of Geneva. This scheme was never given effect to and would appear to have been finally dropped.

CARDBOARD BOX-MAKING MACHINERY.

(*Continued from page* 610.)

Variable-Feed Stitching Machines.—The wire-stitching machines which we have so far dealt with are of the fixed-feed type—*i.e.*, the length of wire

Fig. 78.

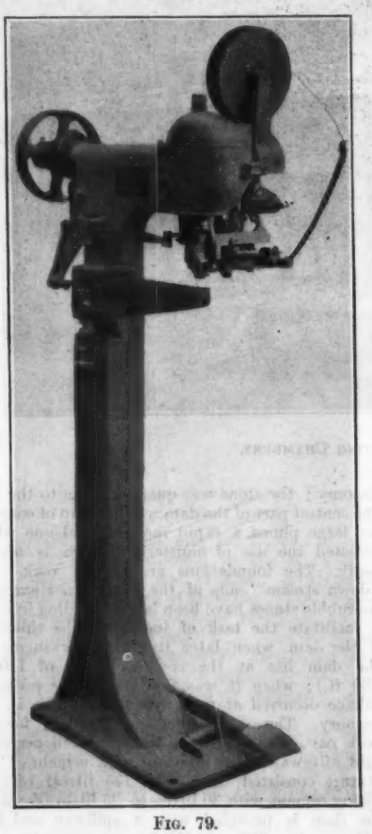


FIG. 79.

cut-off for each stitch is always the same, no matter what the thickness of the material being stitched. Other machines are, however, built in which the length of stitch is automatically varied in accordance with variation in the thickness of the material. This necessarily results in a somewhat more complicated construction, but for many purposes such variable-feed stitching is to be preferred. A somewhat neater job will, as a rule, be produced, and in machines which have to deal with a large range of thickness this point may become of importance. The effect of varying the length of wire cut-off is illustrated in Fig. 78, from which it will be clear that a uniform length of clinch is obtained, no matter what the thickness of the board being stitched.

In our description of variable-feed stitchers it is not necessary that we should deal with the machines as a whole, or with the stitching mechanism, in the way we found necessary in our earlier description of the fixed-feed machines. The two types have much in common, and our present purpose will be served if we confine our attention in the main to the variable-feed arrangements, and to any other features in which the variable-feed machine differs from the simpler fixed-feed machine. A variable-feed machine of the cross-stitch type is illustrated in Fig. 79, annexed, while the upper and more important part of a similar machine, but of the straight-stitch type, is illustrated to a larger scale in Fig. 80, on page 641. The straight stitchers and cross-stitchers differ only that in the case of the cross-stitcher the working head is set round through 90 deg., exactly as in the case of the fixed-feed machines. In our description we will confine ourselves to the straight stitcher shown in Fig. 80, as in this case the operation of the feed-varying mechanism will be more easily followed. As will be seen, both of the machines are of the power-driven type, and their general arrangement of parts follows that of the fixed-feed machines which we illustrated earlier.

The variation of the length of the wire-feed of the machines is brought about automatically by the adjustment of the anvil. Fixed to the anvil there is a caliper stop, which registers with a similar stop fixed to the head of the machine, and when setting for the length of feed, a piece of the material to be stitched is placed between the caliper stops, and they are brought together until they bite the material with an easy grip. This adjustment of the position of the anvil, which is brought about by the hand-wheel and screw, which can be seen on the side of the frame in Fig. 80, automatically and at once makes all necessary adjustments, so that the feeding gear gives the correct length of wire to suit the setting of the caliper stops, and the cutting gear is moved to the correct position to equalise the lengths of the two legs of the staples. As will be seen from Fig. 80, a clamping arm is fitted in connection with the anvil, so that it may be secured in position after adjustment.

As will be clear from Fig. 80, the stitching and feed gear of the machine are driven through a horizontal shaft, which carries the driving pulley on its outer end. A clutch operated by a treadle serves to connect or release the shaft to or from the pulley. The arrangement of this clutch can be seen in the figure. At the front end of this shaft there is a crank which operates the stitching mechanism, while behind this crank there are cams which respectively operate the staple-forming mechanism and the feed. The crank and cams are covered by a guard, which is provided with a door, as can be seen in Fig. 80. In describing the variable-feed arrangement it will be well to approach the matter by considering what takes place when the anvil is moved up or down, as that is the actual motion by which the machine is set, and we may accordingly refer to Fig. 81 and Fig. 82, which show the anvil *a* and its connection to the feed-adjusting bar *b*. As will be seen, the two parts have a sliding connection set at 45 deg., a projecting strip on one part fitting into a slot in the other. The effect of the arrangement is that when the anvil is moved upwards the feed-adjusting bar moves to the left, and when anvil is moved downwards it moves to the right.

Below the feed-adjusting bar *b*, and carried by it, the feed gear and non-return clutch are situated. These are much the same as the corresponding parts in the fixed-feed machine, which we have already described, and their operation in detail need not be dealt with again. It will be clear from Fig. 81 and Fig. 82 that as the feed-bar is moved horizontally by the adjustment of the anvil, the feed gear is moved closer to, or farther away from,

CARDBOARD BOX-MAKING MACHINERY.

CONSTRUCTED BY MESSRS. VICKERS, LIMITED, ENGINEERS, ERITH.

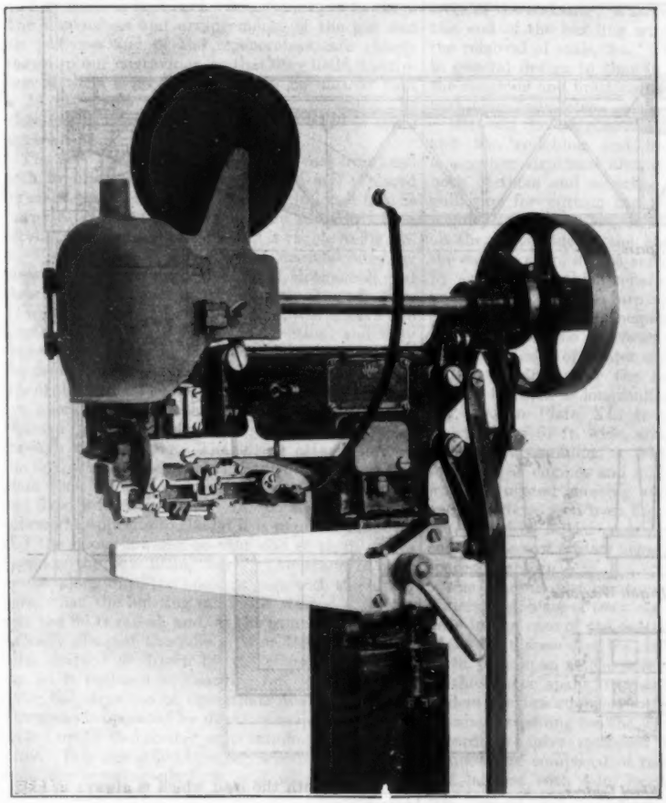
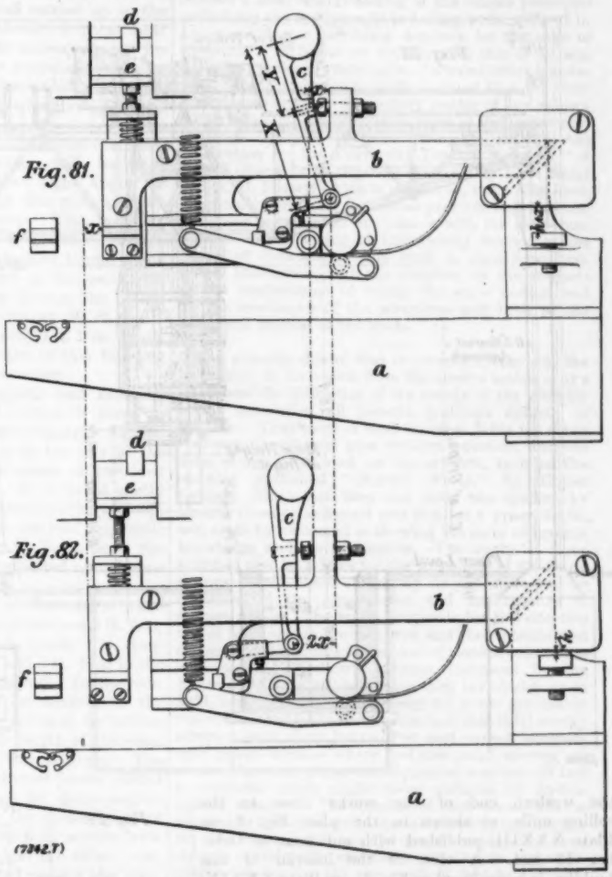


FIG. 80.



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the stitching mechanism. The actual feed is made by the rocking lever *c*, which swings on a fixed pivot, and is connected by a link to the swinging block carrying the steel grip which feeds the wire forward. This rocking lever *c* comes up against a stop in its back position, and, as will be clear from Fig. 81 and Fig. 82, as this stop is mounted on the feed-adjusting bar *b*, the length of swing of the rocking lever is determined by the position of the anvil. As a result the length of wire fed is also determined by the position of the anvil. The rocking lever is actuated by a cam on the main shaft of the machine, which acts on an upper arm of the lever, which is not indicated in Fig. 81 and Fig. 82, but the lower part of which can be distinguished in Fig. 80. The cam is of constant throw, but the stroke of the lever depends on its position of rest, which is determined by the position of the feed-adjusting bar *b*. As can be seen in Fig. 80, the lever is held up against its stop by a helical spring, and when the position of the feed-adjusting bar is as in Fig. 82, the upper arm of the lever is not acted on until the cam has completed part of its revolution, so that the full throw is not utilised and a full stroke is not given to the lever *c*.

The proportions existing between the movement of adjustment of the anvil and the length of the feed are indicated in Fig. 81 and Fig. 82. In Fig. 81 the distance between the caliper stops—that is, the thickness of material being stitched—is indicated as $h + x$, and in Fig. 82 the same dimension is indicated as h, so that between the two positions shown the adjustment for thickness of material is equal to x. As shown in the figures, however, the movement of the end of the rocking lever as a consequence of this adjustment is $2x$. This follows because the proportions of the rocking lever are such that $X = 2Y$. This multiplication of any adjustment for thickness of material by 2 is, of course, necessary because the two legs of the wire stitch have each to be lengthened when a change from any material to a thicker is made.

In addition to altering the length of wire feed, it is also necessary that the adjustment of the position of the anvil should alter the position of the cutting-off gear. If this were not done, and if the length of wire were altered while the cutting-off gear remained in the same position, stitches would be formed having legs of unequal length. The method by which this position of cutting-off is varied is indicated at the left-hand side of Fig. 81 and Fig. 82. The cutting-off knife and cutting-off tube are carried by the feed-adjusting bar *b*. They are actuated by a cam on the main shaft, which acts on a roller which is indicated at *d* in the figures. This roller is carried at the top of a slide *e*, which works between fixed guides forming part of the main frame. Below this slide there is an adjusting screw which forms part of the reciprocating cutting-off member. As the cam rotates the slide *e* is depressed at the appropriate moment, and the cutting-off knife is driven downwards through the adjusting screw. As the cam continues to rotate the cutting-off knife rises, after it has done its work, under the action of the spring, which can be seen in Fig. 81 and Fig. 82. As the cutting-off gear is carried by the bar *b* it will be clear, as it is shown in the figures, that as the bar is moved horizontally the cutting-off gear moves to a new position under the slide *e*. The stroke of the gear does not alter in any way, but its position alters in respect to the loop bar, which is indicated at *f* in the figures. This arrangement results in the wire stitch always being cut off at such a point that after cutting, it projects an equal distance on each side of the loop bar. When the wire is cut off close to the bar the feed is small, and for the next stitch the wire will only be fed so that it projects a short distance on the far side of the loop bar. When on the contrary the wire is cut off at a greater distance from the bar the feed is greater, so that at the next feed the wire will be moved so that it projects a greater distance beyond the far side of the bar.

In other particulars the variable-feed machine follows the arrangement of the fixed-feed machines. The stitching gear is driven by a crank at the end of the main shaft, but its arrangement of former, loop-bar and driver follows that already described. The clinching mechanism is also similar, but attention may be directed to the method of driving the clinching push-bar, which is necessarily different from that of the fixed-feed machine, owing to the difference in the main driving arrangement of the machine. As clearly shown in Fig. 80, a cam carried by the shaft acts on a roller carried on the top of a link, which is attached to a bell-crank lever which acts on the end of the push-bar. Machines of this class are built in seven sizes, for boxes from 12 in. to 36 in. long. In general they are designed for any thickness of work up to $\frac{3}{4}$-in., but heavier machines are also built. The staples may be $\frac{3}{4}$-in., $\frac{1}{2}$-in., or $\frac{5}{8}$-in. wide. The speed of operation of the machines is the same as that of the fixed-feed machines, the 12-in. machine, for instance, working at 180 stitches per minute. This machine consumes $\frac{1}{4}$ h.p.

(To be continued.)

THE MOSSEND STEEL WORKS AND ROLLING MILLS.

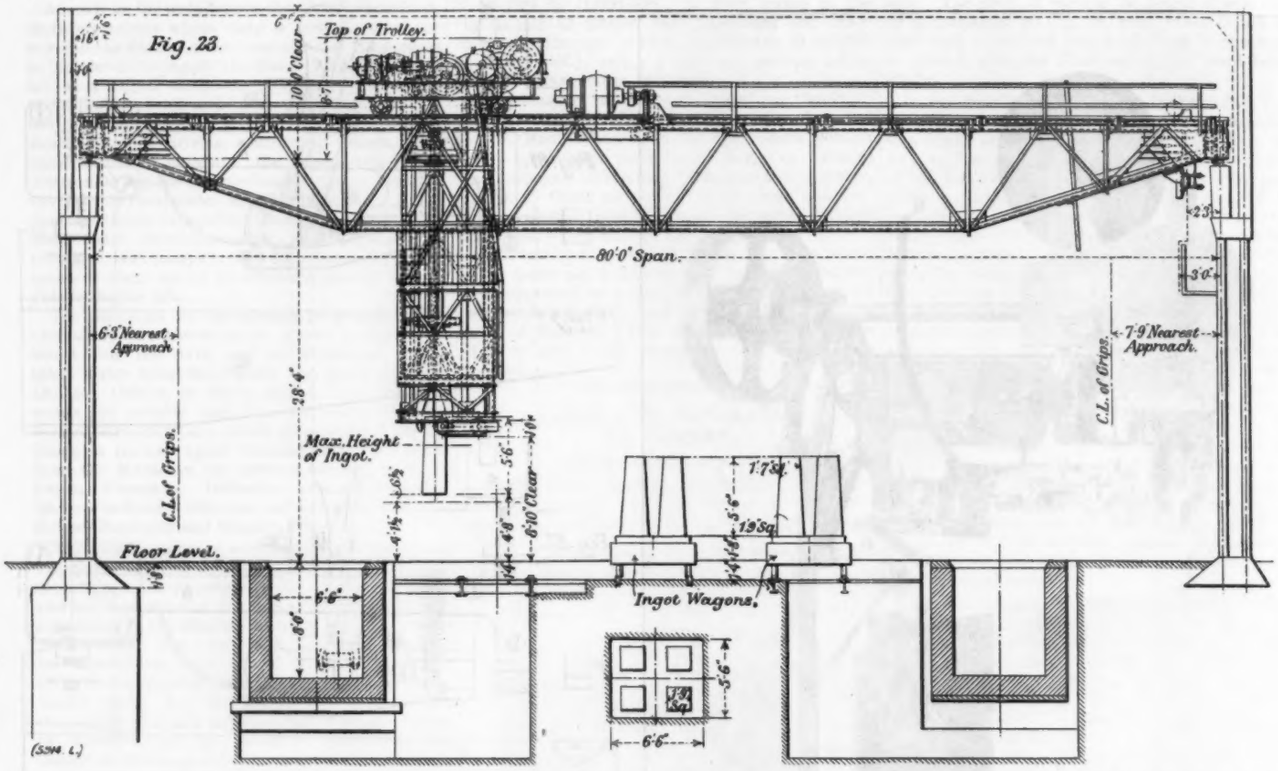
(Continued from page 606.)

WHEN the moulds have been removed, as described in the preceding article, the train of cars with the hot ingots still standing on them is pushed along to the soaking pits, which, as previously mentioned, are located in the same building as the ingot stripper. The building is situated at

3-TON INGOT CHARGING MACHINE AT THE MOSSEND STEEL WORKS.

CONSTRUCTED BY THE WELLMAN SMITH-OWEN ENGINEERING CORPORATION, LIMITED, ENGINEERS, LONDON.

Fig. 23.

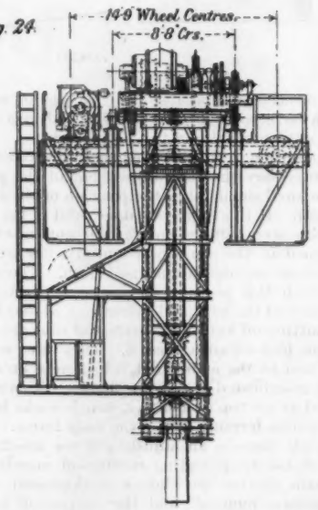


the western end of the works close to the rolling mills, as shown in the plan Fig. 2, on Plate XXXIII, published with our issue of October 13 last. A view of the interior of this building is reproduced in Fig. 25, on Plate XXXIX, and a transverse section of it is given in Fig. 26, on Plate XL. The total length of the building is 360 ft., and the width of the main part is 83 ft. 7 in. On the north and south sides, however, there are lean-to sheds, 200 ft. long, with roofs of 33 ft. span under which the regenerators and the air and gas valves for the soaking pits are situated. The columns which support the roof and the gantry for the charging machines are spaced at 40-ft. centres, and the roof and walls are covered with corrugated iron sheets, except on the northern side of the roof, which is glazed. In the lean-to buildings, the corrugated iron sheets are carried down to a distance of 6 ft. 6 in. from the ground, the lower part, in general, being left open, although, in the case of the building on the north side which is more exposed to the weather, a 9 in. brick wall has been built up to the level of the sheeting. In the part of the main building housing the stripper, the corrugated sheeting is only carried down to the level of the bottom of the crane girders.

There are four soaking pits having seven holes each, and each hole is arranged to take four 3-ton ingots. The four pits are arranged in two parallel rows, one of which can be seen in Fig. 25; the other row on the opposite side of the building is not visible in the illustration.

For serving the pits, two ingot-charging machines, one of which is shown in Fig. 25, are installed. The design and construction of these machines, which were supplied by the Wellman, Smith Owen Engineering Corporation, Limited, Kingsway, London, W.C. 2, can be followed from the drawings reproduced in Figs. 23 and 24, annexed, which also give the main dimensions. In general design the construction resembles that of an overhead crane, the main girders of the open lattice-braced type, being supported on end carriages, each of which runs on two travelling wheels. On each side of the

Fig. 24.



main girders, the span of which is 80 ft., is an auxiliary girder supporting the travelling gear.

The motor for this is placed near the centre of the span and drives a longitudinal shaft, on the ends of which are mounted pinions engaging with steel spur rings bolted to the travelling wheels; the arrangement, which can be followed by examining Figs. 23 and 24, gives a travelling speed of 400 ft. per minute. The charging trolley is mounted on four double-flanged wheels running on rails fixed to the upper flange of the main girders and driven through spur-reduction gearing by a motor mounted on the trolley; the cross traverse speed is 300 ft. per minute. From the trolley is suspended a steel framework which acts as a guide for the gripping mast, and the driver's cab is also attached to this framework, as shown in Fig. 24, so that the driver travels with the load which is always in his field of vision.

The hoisting gear, which is mounted on the trolley frame, consists of a motor driving through spur-reduction gearing, a cast-iron drum with turned right-hand and left-hand grooves for the hoisting rope. The gripping gear and mast are suspended from the hoisting rope with volute springs interposed in order to reduce the shock on the rope when the load is suddenly applied. The mast, it should be mentioned, has sufficient stroke to enable fallen ingots to be picked up from the bottom of the soaking pits, and a 3-ton ingot can be hoisted at the rate of 40 ft. per minute. In addition to the hoisting and lowering motion, the mast can be slewed in any position at 5 r.p.m., a separate motor being provided for this motion. The gripping gear consists of a pair of steel tongs provided with points near their lower ends, which penetrate sufficiently into the ingot to hold it firmly. The tongs are connected by links, which can be seen in Fig. 23, and the upper ends work in inclined slots formed in the mast as indicated by dotted lines in the illustration. The effect of the load is, of course, to pull the tongs downwards in the slots, so that the upper ends open out and the lower ends close together and grip the ingot. The latter is released by pulling the tongs upwards relatively to the mast by means of a chain attached to the connecting link and operated by a separate motor.

In connection with the working of this machine we may point out that the cars carrying the hot ingots from the stripper are brought right under the charging machine, as is also the small electrically propelled car used to convey the ingots from the soaking pits and deliver them on to the live rollers of the cogging mill. The charging machine, is thus mainly employed for hoisting and cross-traversing, the longitudinal travel being reduced to a minimum. This has the effect of reducing wear and tear as far as possible, and consequently tends to keep down the cost of upkeep.

The design of the soaking pits, for which Messrs. Beardmore's engineering department was responsible,

is illustrated in Figs. 34 to 37, on Plate XLI. As will be gathered from the illustrations, they are of the gas-fired regenerative type, and, as previously mentioned, each furnace has seven holes for the accommodation of four 3-ton ingots; the holes each measure 5 ft. 6 in. by 6 ft. 6 in. by 8 ft. deep. The dimensions and arrangements of the gas and air passages and of the regenerators, are clearly shown in our engravings, so that very little description of them is necessary. It will be noticed that a 33 in. Dyblie valve is used for reversing the direction of the gas and that the air valve is 40 in. square.

The lids covering the holes are of cast iron lined with firebrick, and they are removed and replaced by small travelling cranes specially designed for the purpose. Two of these cranes are provided, each serving 14 holes, and one of them is visible in Fig. 25, on Plate XXXIX. They were manufactured by Messrs. Alexander Jack and Co., of Motherwell, and their design and construction is clearly shown in Figs. 27 to 32, on Plate XL. The cranes, which have two hoisting hooks, have no slewing motion, and they travel on rails running parallel with the pits, so that the centre line of the hooks is always over the centre line of the pits. The hoisting and travelling motions are operated by independent motors, the former through a worm reduction gear and the latter through spur gearing. The lifting attachment on the lids, which weigh about 3½ tons, consists of two plain rods bent to the form illustrated in Fig. 27 and fixed 2 ft. 9 in. apart. In operation, the crane is brought opposite to the lid it is required to move, and the hooks lowered so that one of them comes between the two lifting bars. The crane is then moved along until the hooks engage with the lifting bars, when the hoisting motion is started. In this way the lid is raised, and, at the same time, moved laterally clear of the hole. After the ingots have been charged or drawn by the charging machine, the lid is replaced by carrying out in the reverse order the sequence of operations above described. The crane is operated by direct current at 220 volts picked up by two trolley arms running on overhead wires. It is controlled by a boy who need not move from the working platform and who requires no external assistance for removing and replacing any of the lids.

Gas for firing the soaking pits is supplied by six Morgan producers with George feed of similar design to those previously described for supplying gas to the melting furnaces. The producers are placed in a single row in the open on the southern side of the soaking pit building, as shown in the plan reproduced in Fig. 2, on Plate XXXIII, published with our issue of October 13 last. The coal and ash-handling arrangements for these producers are also practically identical with those of the gas plant already dealt with.

The electrically-propelled car, which, as mentioned above, is employed for conveying ingots from the soaking pits to the cogging mill, can be seen towards the right-hand side of Fig. 25, on Plate XXXIX. The ingot, it should be explained, is placed by the charging machine on a cradle which is pivoted on to the car frame and which normally stands in a position slightly inclined to the vertical. As the car approaches the train of live rolls of the cogging mill, a roller attached to the cradle, and projecting on one side of the car, engages with a ramp placed parallel with the track, and the effect of this is to tilt the cradle into the horizontal position over the live rolls. The ramp is so placed that when the cradle reaches the horizontal position, the cross-bar, which normally supports the ingot, comes between the first pair of live rolls, at a lower level than the tops of these rolls. Thus the ingot then rests on the rolls and is withdrawn by them from the cradle and conveyed to the cogging mill. Current for propelling the car is picked up from trolley wires placed in a conduit below the level of the track and protected by removable steel-plate covers shown in Fig. 25.

The cogging mill, and the engine driving it, are situated in a building adjoining the soaking pit building on the eastern side and running at right angles to it, as indicated in the plan, Fig. 2, on Plate XXXIII *ante*. The building is 190 ft. long by 61 ft. wide, and the columns are designed to carry a 50-ton crane which serves the mill. The northern end of the building opens into the heavy steel foundry which forms part of the casting shop, but the southern end is covered with corrugated sheeting to within 6 ft. 6 in. of the ground, and completed with a 9-in. brick wall carried up to the level of the sheeting; a large double doorway near this end of the building admits railway trucks for the removal of scale, &c. The steelwork is similar in general design to that in the building covering the roughing and finishing mills which we shall deal with more fully later.

Between the cogging-mill building just described and the roughing and finishing mill building, is another structure arranged at right angles to both of them and covering the live rolls and the guillotine for cutting the blooms. This building, which is 183 ft. in length and 84 ft. wide, is open on the north side to the heavy steel foundry and the casting shop, and is enclosed on the south side by a 9-in. wall which separates it from the boiler-house. The columns are spaced at 30 ft. 6 in. centres and the roof principals are 10 ft. 2 in. apart, but as there is no overhead crane in this building the steelwork is of lighter construction.

The building over the roughing and finishing mills, of which a longitudinal section is given in Fig. 33, on Plate XL, is approximately 230 ft. in length by 61 ft. wide, and, as in the case of the cogging-mill building, a 50-ton crane is provided to serve the engines and mills. It is roofed partly with corrugated sheeting and partly with glazing, and, as will be seen from Fig. 33, the roof principals are carried by lattice girders, 14 ft. 3½ in. deep, the ends of the roof girders being supported on columns spaced as shown.

The columns just mentioned also carry the crane girders, which are of the plate type and are 3 ft. 6 in. deep in the case of the two 40-ft. spans, 7 ft. deep in the 84-ft. span over the mills and 5 ft. deep in the 65 ft. 6 in. span at the northern end. In the case of the longer spans, it should be mentioned, the girders are braced back to the columns by lattice framing extending for the whole length of the span in order to give increased lateral stiffness. The columns are composed of rolled steel joists, plated and latticed with 4-in. by 3-in. by ⅜-in. angles. One joist of each column takes the greater part of the crane load, and is of 14 in. by 6-in. section with 12-in. by ½-in. flange plates, while the other joist, which is latticed to the first and carries the roof, is of 15-in. by 6-in. section without flange plates. This joist is carried up from the base to the bottom of the roof girder, and an extension piece, to which the roof girders are connected, is attached to this joist by 15-in. by ½-in. flange plates. At the extreme northern end of the building, the roof and crane girders are carried by two of the columns of the casting shop which were specially reinforced for the purpose.

The outgoing live rolls from the finishing mill are covered by a building 222 ft. 6 in. in length and 86 ft. 3 in. wide, of similar design to that previously referred to between the cogging-mill building and the roughing and finishing mill building. The rolls are continued through the northern end of another building in which the repair shops and light steel foundry are situated, and thence pass on to the cooling bank. The south end of this is housed partly in a building measuring 122 ft. by 90 ft. 6 in. wide, and having a height from the floor level to the underside of the roof principals of 30 ft. 6 in., while the north end is housed in an extension to the billet shearing and stocking bay.

On the south side of the building with which we are dealing, the columns are spaced at 30-ft. 6-in. centres, and the principals, which are spaced 10-ft. 2-in. apart, are carried on roof girders extending between the columns. At the northern end, a single roof girder, of 122 ft. span, and supported on two of the columns of the adjoining casting shop, carries the whole of the principals without any intermediate support. The roof is glazed entirely on the north side and covered with corrugated sheeting on the south side. Beyond the cooling bank building are the loading banks, and south of these is situated the rail-finishing plant. We shall deal with these in a subsequent article, together with the plant contained in the buildings above described.

(To be continued.)

NOTES ON NEW BOOKS.

In the writing of an elementary text book on any subject the aim of the author should be to give his readers a clear understanding of the simple principles underlying the machines he is dealing with, without in any great degree sacrificing accuracy for the sake of simplicity. If books are written with this as an aim the later studies of students have a substantial foundation. It must always be borne in mind that the clear understanding of the elementary matter of any subject is the most important consideration in any scheme of training. It is for these reasons we welcome the publication by the University Tutorial Press of "*A Second Course in Engineering Science*," by P. J. Haler and A. H. Stuart, which is sold at 5*s.* net. The book is primarily intended for second-year evening students in classes organised in accordance with the Memorandum on the Teaching of Engineering Science of the Board of Education. The work is clearly written, amply illustrated, and the chapters on the subjects of the transmission of energy by wave motion and on the mechanics of the aeroplane add both to the value and interest of the book.

The winning of land that is covered by the sea, the protection of our coasts from the erosive action of the water and the utilisation of the energy of the tides for power generation all present problems difficult of solution. That there is work in these fields for many resourceful engineers goes without question, and the issue of any good work on the subjects, such as the recently published "*Marine Works*," by Ernest Latham, which has been put upon the market by Messrs. Crosby Lockwood and Son, at a price of 16*s.* net, must be welcomed as showing the state of present knowledge and its application. The study of wave action is used as a basis for the treatment of the many actions on the shore caused by its operation and to questions of the construction and maintenance of marine works. The many proposals for the effective use of tidal energy are reviewed and their possibilities discussed. The limits of first cost of plant in connection with any hydro-electric scheme, indicated by the Electricity Commissioners after their investigations in 1921, make the use of tidal energy for power generation out of the question. Despite the fact that tidal energy schemes with their heavy first cost cannot compete with power schemes where fuel and prime movers are in use, there are places where neither coal nor oil fuel is available which might prove suitable for hydro-electric schemes. The number of such places will be reduced as fuel-oil distribution is extended, and usually the tidal schemes will be ruled out of consideration even though considerable expense is entailed in the alternative scheme for the transport of fuel to the site. The controversial question of the economical advantages and disadvantages of deep-water quays as compared with the provision of equivalent accommodation by means of dock construction is reviewed in an interesting chapter. The legal aspects of the various questions relating to maritime construction are not forgotten, and the references to test cases will prove of great service. The book is well written, and may be recommended to all who are interested in the problems connected with marine works.

The use of a system of costing for the running of motor vehicles is advocated in a small, but informative, publication issued by the Albion Motor Car Company. The first cost of a motor vehicle may not be the most significant factor in the cost per mile run, as the running charges of a cheap machine may be very high. The total cost of running for a whole fleet of cars, although a common gauge of the value of motor transport gives very little information about the merits of different machines. The compilation of weekly returns for each car, on forms with columns for each item making up the standing and running charges as well as the mileage run, gives the means of determining the total cost per ton-mile of duty which must always be the most indicative factor in the estimate of the value of a car. The use of such a table by users of a number of different makes of vehicles would provide very interesting information on the value of the various units and makes.

The "Milegal" Petrol Meter.—A meter has been put on the market by the B. and R. Manufacturing Company, Winchester House, Birmingham, which is intended to indicate the number of miles a motor car is running to the gallon of petrol. The meter is provided with an indicator dial and can be fitted to the dashboard in the supply line between the tank and carburettor. The dial reads direct in miles per gallon. A three-position cock is included in the arrangement. In one position the supply is diverted from the carburettor to fill the meter; in the second the meter is put in connection with the carburettor and the rate of consumption is indicated, and in the third the meter is cut out and the fuel tank connected again with the carburettor and the car run in the ordinary way.

TWO-STROKE ENGINES AT THE MARINE AND SMALL CRAFT EXHIBITION.

CONSTRUCTED BY MESSRS. REED'S PATENT ENGINE COMPANY, LIMITED, SOUTHAMPTON.

Fig. 1.

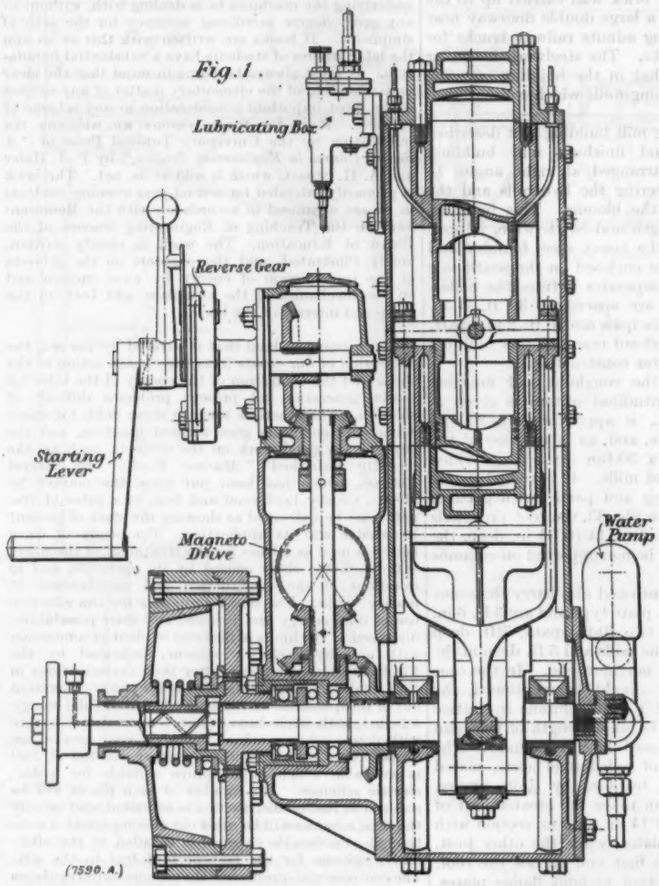
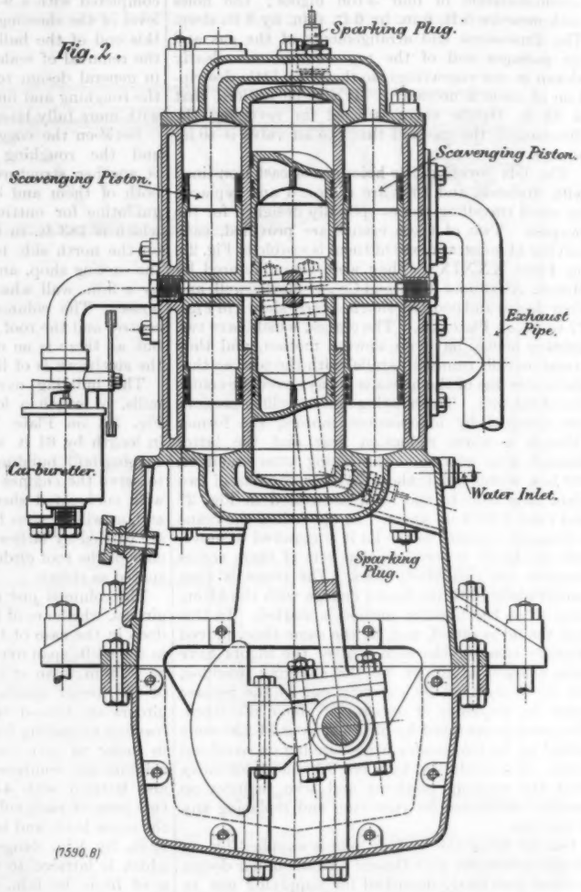


Fig. 2.



THE MARINE AND SMALL CRAFT EXHIBITION.

THE exhibition held in the Royal Agricultural Hall, Islington, London, from November 14 to 24 was a most successfully organised show, and that such a combined display of boats propelled by oars, sails or engines was desirable is manifest from the interest shown by the boating public. It is, of course, to be regretted that it was not possible for all who make power boats and their equipment to exhibit, for there would then have been a greater number of exhibitors and, perhaps, an exhibition more representative of the products of the whole industry. Despite the absence of many of the foremost firms in the country, there was much of interest to those concerned with the propulsion of small craft, and designs of plant of exceptional merit were shown on many of the stands. The two-stroke engines shown by Reed's Patent Engine Company and by Bruntons, of Sudbury, are examples of considerable interest, which show one trend of development in marine motors. This cycle of operations has found great favour in the small outboard types of engines, but its advantages for larger engines suitable for inboard installation are evidently impressing some of the more enterprising marine motor builders, who are aiming at the reduction of those disadvantageous conditions formerly experienced with this type of engine, especially when working double-acting.

Reed's Patent Engine Company, of Hythe, Southampton, showed double-acting two-stroke engines of two types. Of these, one, which runs on petrol or paraffin; is illustrated in Figs. 1 and 2 on the present page, while the other is a crude oil type shown in Figs. 3 and 4.

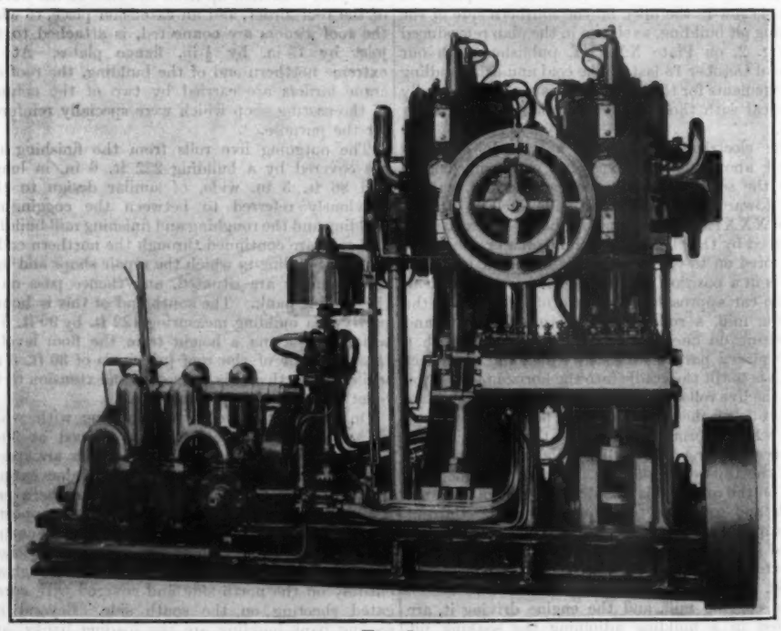


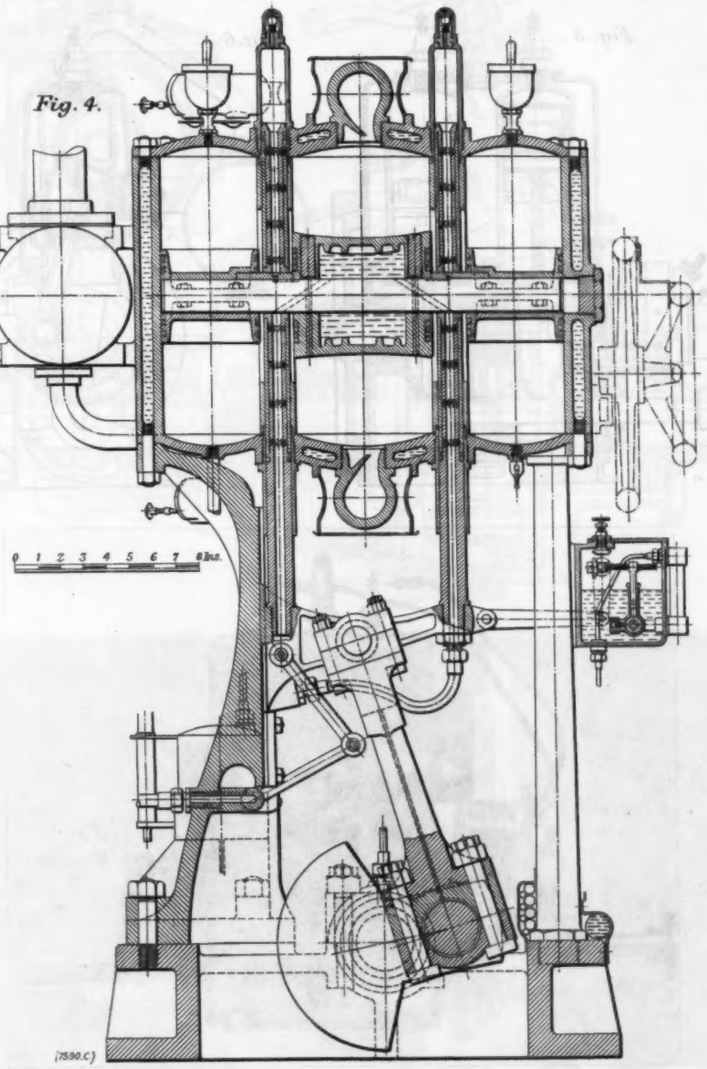
FIG. 3.

In the light oil type the moving system consists of the pistons for the two ends, which are cast separately and bolted together, and two pump plungers, situated one on each side of the piston. The cylinders are cast separately but the water jackets and pump cylinders are cast along with them. Through the gudgeon pin a connecting pin

TWO-STROKE ENGINE AT THE MARINE EXHIBITION.

CONSTRUCTED BY MESSRS. REED'S PATENT ENGINE COMPANY, LIMITED, SOUTHAMPTON.

Fig. 4.



passes which is used to communicate the piston movements to the pump plungers. The connecting rod is of the forked type, and provided with brasses at its ends which work on the gudgeon pin. The explosive mixture is drawn into the pumps through non-return valves. When the pistons are passing downwards, gas is introduced from the top sides of the two pumps into the bottom end of the cylinder during the first part of the stroke. On further travel of the pistons, the pressure is raised by compression. After this compression stroke is completed, the explosion takes place, the mixture being ignited by the use of a sparking plug passing into the clearance volume at the side. Following the explosion the burnt gas is expanded, and towards the end of the stroke is expelled. The pistons uncover ports in the cylinder walls in the way usual with engines of the two-cycle type, and in the ordinary sense the engine is a valveless one, except for the non-return valves through which the mixture of gas and air is admitted to the pumps. The crank-case is cast in halves, the top half of which has formed upon it the lower cylinder cover. The top cover of cylinder and pumps is removable to facilitate cleaning. Slots cut in the cylinder walls allow freedom of motion to the gudgeon pin, and others on a diameter at right angles to these are used for the connecting pin which joins up the pistons and pump plungers. The crankshaft is provided with two bearings, which are fitted with white-metal liners. A double ball race type of thrust block is fitted just behind the after bearing. A small plunger pump which is used for circulation water receives its drive from the forward end of the crankshaft. The magneto drive is obtained through bevel gearing from the crankshaft. The starting handle gives motion through these wheels, and another pair of bevel wheels on the top of the vertical shaft.

The engine illustrated is a 6-h.p. unit and has a bore of 2¾ in. and stroke of 3 in., while its total weight is 250 lb., including carburettor and magneto. A series of multi-cylinder engines of the same design has been introduced.

The crude oil type of engine, of which a two-cylinder example of 50 h.p. was exhibited, and of which illustrations are shown in Figs. 3 and 4, has many interesting features.

The characteristic design of the small engine as regards the position of cylinders and pumps is adhered to in this engine, but the motion from the piston is taken by means of side rods to a cross-head below the cylinder and to which the gudgeon pin is connected. The stroke and cylinder diameter of this engine are both 6 in., while the speed of running is 300 r.p.m. The form of the hot bulb may be seen from the section, Fig. 4. A starting lamp, or alternatively an electric system of heating, is employed. No water drip is used, but the temperatures of the bulbs are automatically controlled by the engine, by the use of a valve which allows a stream of cold air to pass into the cylinder before the change of fuel. The side rods are made of oil-hardened steel, and packing pieces are shaped to fit into flats cut on the rods. These packing pieces are made to press against the cylindrical walls within which the side rods act, by means of small springs situated in holes cut through the rods. The positions of these springs are clearly shown in Fig. 4. The pumps operate in the same way as in the small light oil engine, that is to say, the supply from the underside of the pump cylinders is taken to the top end of the main cylinder and from the top sides of the pumps to the bottom end of the engine cylinder. The transfer ports for these operations are placed beside the side rods between the main and the pump cylinders, but are not shown in the drawing. Separate sets of fuel and air pumps are used for each cylinder, and they are of ample capacity to withstand a heavy overload. The photographic view, Fig. 3, page 644, shows the general appearance of the engine. Above the lubricators, details of which can be seen in the line diagram, Fig. 4, are situated the control wheels.

The first movement of the starting wheel puts an air pressure upon the oil in the lubricator chamber, and supply is obtained for all parts of the engine immediately. Motion is taken from the control wheels to regulate the engine speed, to control the direction of rotation and to operate the air starting valves. The air starting distributor is situated on the governor shaft. The fuel pumps are driven from eccentric rods on the main shaft, and the heating chamber for the oil is situated on the back of the engine. The oil control box is provided with channels which can be made to register with the outlets to which the cylinder connections are made. Two small single-stage air compressors are provided in the complete two-cylinder installation and are connected to air vessels, which can be seen in Fig. 3. Beside the air compressors are the bilge and circulating pumps.

Messrs. Bruntons, of Sudbury, exhibited a two-cylinder engine working on the two-stroke cycle, in which there are some quite novel features. The cylinder diameters are 2⅝ in. bore and the stroke is 3 in. On brake test, 6 h.p. was obtained when running at 1,000 r.p.m., which was raised to 8 h.p. at 1,400 r.p.m. The engine is illustrated in Figs. 5 to 7, on page 646. The form of the pistons and cylinders are shown in Figs. 5 and 6. The pistons are of aluminium alloy and are provided with two cast-iron piston rings at the top and a third one at the bottom. The connecting rods are made of nickel-chrome steel and are fitted with phosphor bronze bushes to receive the gudgeon pins, and with roller bearings at the big ends. A double-helical toothed wheel on the crankshaft, at about the centre of its length, engages with another wheel on the lower shaft, for which a speed one-half of that of the crankshaft is obtained. The crankshaft runs in ball bearings. To prevent the air leakage that would otherwise take place an effective oil packing is arranged with the use of a phosphor bronze casting with concentric grooves cut in it. The speed reduction gearing is kept completely isolated from the two separate crank chambers. A positive gear pump, which is driven by a chain from the propeller shaft, is used to circulate the water required for cylinder cooling. Magneto ignition completes the equipment of what constitutes a complete power unit. The endeavour to produce a small two-stroke unit running under conditions suitable for obtaining high efficiency and at the same time with a speed for the driving shaft which is suitable for the use of a reversible propeller, has engaged the attention of engineers for a considerable time, and this installation is not lacking in interest to all who have been faced by this problem.

Messrs. Dixon Brothers and Hutchinson, Limited, showed many models of their engines, representative of the sturdiness and substantial construction of the engines of British design. In these engines the practice is to make the cylinder and water jacket in one casting and extend the water space to provide

cooling for the exhaust valve stem. The valves are fitted into a recess at the side of the top of the cylinder. An overhead valve is used for the inlet purposes, and is operated by a small lever receiving its motion from the camshaft through a substantial tappet and a push rod, which is made of steel tube. The weight of the piston is reduced by the drilling of holes in the lower part to lessen the inertia forces. Stampings of H-section are used for the connecting rods, which are provided with white metal die-cast bushes. The cams are keyed to the shaft and secured in position by pins and driven by either spur gearing or chains. In all models the camshafts can be quickly removed by slackening off the bolts holding the bearings in place. Between each pair of cranks there is a bearing, lined with white metal. The water circulation is effected by means of the Woolston gear pump, manufactured by the firm, and the oil for lubrication purposes is delivered to distributing pipes within the crank-case by the use of pumps of either the plunger or gear type. When the engine is to be run on paraffin, arrangements are fitted for either starting with petrol or with the assistance of a blowpipe heating system.

The Kelvin engines with single sleeve valves, built under the Burt-McCullum patents, were exhibited by the Bergius Launch and Engine Company, of Glasgow. The single sleeve has a motion which is the combination of a reciprocating vertical movement and a turning action upon the sleeve. Double inlet and exhaust ports register with ports leading through the cylinder walls to permit the entry and exhaust of the gases.

Reversing the direction of running of a power boat, however small, is a necessity. As the engines are usually constructed to run in one direction only the reverse action must be obtained by the use of separate gear. There are three main methods of obtaining the reverse movement that is necessary: First, the use of propellers in which the blades are not fixed but can be set at angles suitable for motion in the ahead or astern direction; second, the use of a propeller with fixed blades, but with a separate reversing gear interposed between the engine shaft and the propeller shaft; and third, the use of an enveloping rudder in two parts, which is fitted around a fixed propeller and which can be set in positions to change the direction of the water leaving the propeller, for the purpose of causing reversal of motion of the boat. The first two methods were illustrated by many examples in the show, but the third, which has a continuously growing use, was not represented.

In small boats, movable-bladed propellers have proved quite suitable for every service, but in heavy work the separate reverse gear is usually favoured. Epicyclic gearing is commonly used in these gears, and clutches are provided so that the engine can be started while free from load.

A reverse gear with many interesting features and of substantial construction, shown by Messrs. Dixon Brothers and Hutchinson, Limited, of Southampton, is illustrated in Figs. 8, 9 and 10, on page 647.

The unit consists of an epicyclic train of wheels and a clutch with the gear requisite for its operation, set up within a case which is in two parts, bolted together. The shafts are provided with ball bearings, and a double thrust bearing is incorporated in the design to take the thrust on the propeller shaft. The top half of the housing surrounding the mechanism can be removed by unscrewing the nuts on the case, for the purpose of inspection of the gears and making any adjustments that may be necessary. It is possible to run ahead with the top half of the case out of position, and the advantage of this is evident to all who have had experience of testing the setting after making adjustments to a reversing gear. An effective system of oil throwers and catching devices ensures continuous and sufficient lubrication. The holding-down brackets or lugs are entirely separate from the casing, but are bolted to facings upon it. Difficulties of exact alignment are removed by the use of screwed bosses on the holding-down brackets, which after adjustment to the exact requirements can be run in with lead and thus fixed permanently. To prevent the exertion of any pressure by the spring on any fixed part of the mechanism, the spring, which actuates the clutch for the ahead drive revolves along with the shaft. The simple turning of a nut and the locking nut beside it, on the spring sleeve surrounding the end of the propeller shaft, is all that is necessary to adjust the ahead gear, and the adjustment of the band brake to alter the working of the astern gear is effected by altering the setting of lock nuts which are outside the case. The cam lever is made in the form of a bell crank, with a curved end. Any change of its position puts the clutch into or out of action.

The ahead drive is by the multiple cone clutch with a direct spring pressure, which forces the cones together. When the gear is set in this position the gear case and the shaft revolve as one solid entity, and the gear-case and clutch give the advantage of additional flywheel action.

When the gear is placed in such a position that the motion given by means of the cam lever leaves the spring sleeve cone free from the clutch no motion is carried through to the propeller shaft and the neutral position is obtained.

Reverse motion is got by further movement of the cam lever, which is accompanied by the operation of the brake on the casing. The drive is then through the epicyclic gear and the direction of rotation of the propeller shaft is that necessary for astern running.

Ample dimensions of gear wheels, clutch and all other working parts are conspicuous in this gear and ensure the reduction of wear and breakage troubles.

An example of a reversing gear which was shown on the stand of the Evinrude Motor Company, and in many complete power units exhibited throughout the show, is shown in Fig. 11, page 647.

This gear, known as the "Paragon," is a simple and compact unit, making use of epicyclic gears and friction clutches. The centre toothed wheel is keyed to the engine shaft and its teeth are in mesh with those of four smaller pinions, of which the shafts are mounted on the main casing or drum. This main casing has an encircling brake band. Surrounding the set of four pinions there is a drum with teeth cut on the inside cylindrical face, which are in mesh with the pinions. This drum is keyed on to the propeller shaft. A friction clutch of the multiple disc type is situated next to the gear wheels, the plates being connected alternately to

TWO-STROKE ENGINE AT THE MARINE EXHIBITION.

CONSTRUCTED BY MESSRS. BRUNTONS, LIMITED, ENGINEERS, SUDBURY.

Fig. 5.

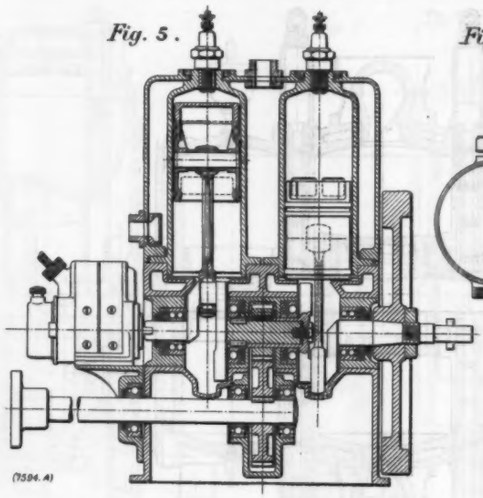
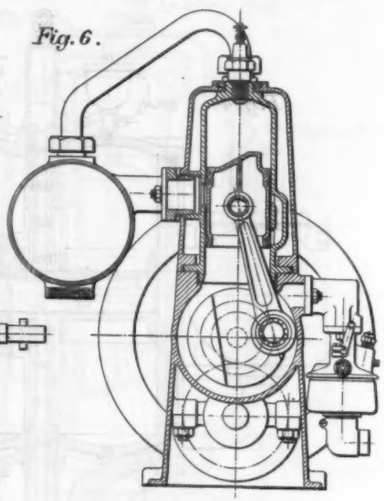


Fig. 6.



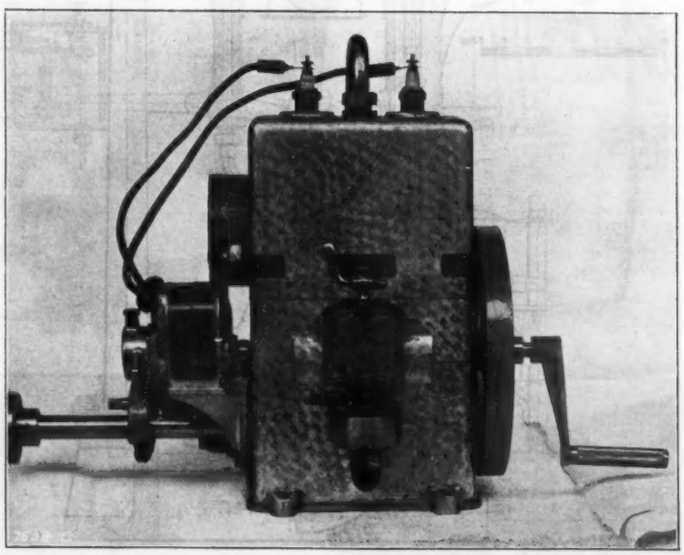


FIG. 7.

EXHIBITS AT THE MARINE AND SMALL CRAFT EXHIBITION.

Fig. 9. CROSS SECTION, LOOKING AFT.

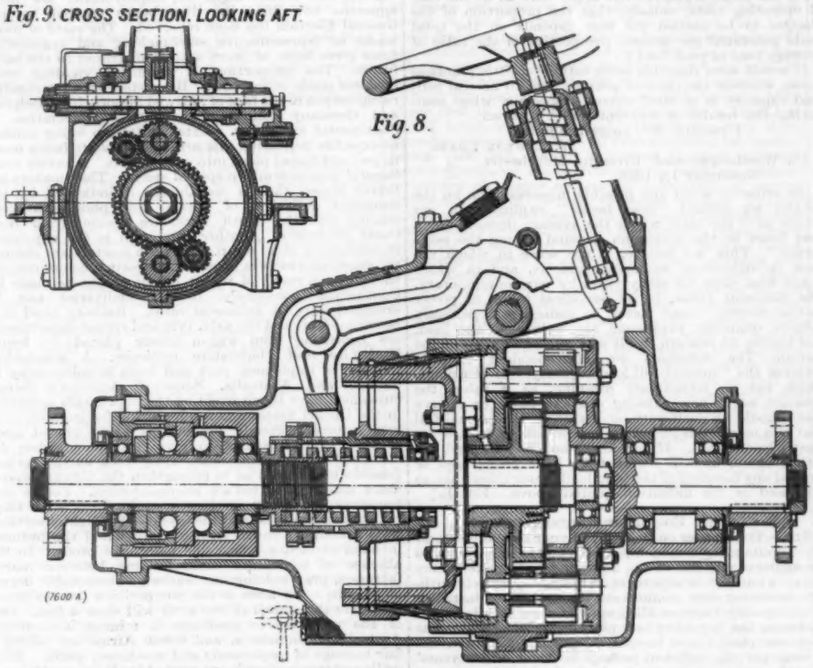


Fig. 8.

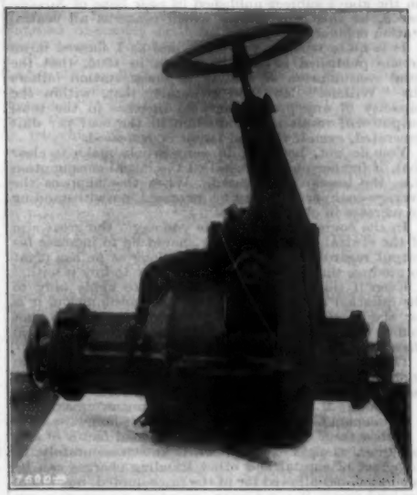


FIG. 10

FIGS. 8, 9 AND 10. REVERSE GEAR; MESSRS. DIXON BROTHERS AND HUTCHINSON, SOUTHAMPTON.

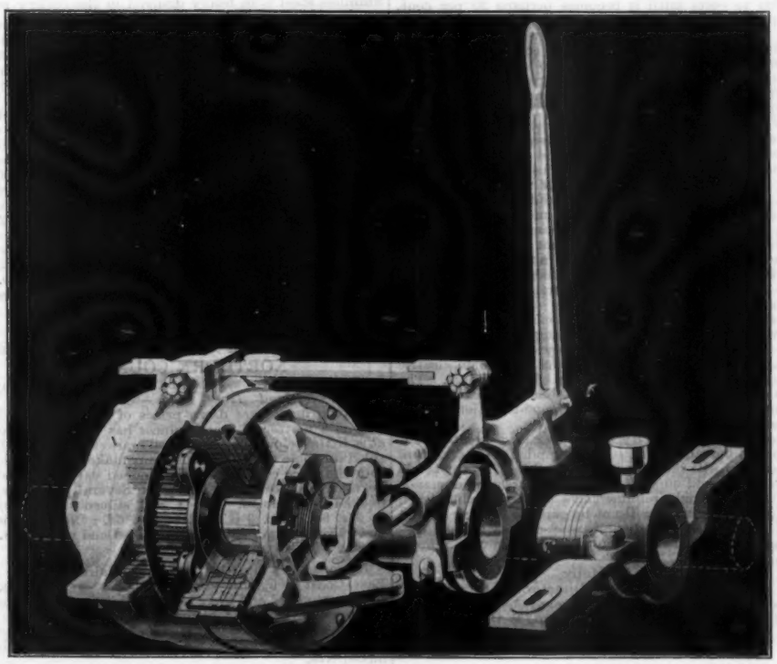


FIG. 11. PARAGON REVERSE GEAR; MESSRS. CHARLES CHURCHILL AND CO., LIMITED, LONDON.

the casing and to the propeller shaft. When the operating lever is in the mid-position the clutches are free and the toothed wheel on the main shaft simply turns the pinions and their casing.

For running ahead the control lever is pushed forward, which brings the plate clutch into action, whereby the casing becomes connected to the propeller shaft and the power is transmitted directly without the use of the gears.

To reverse the action, the control lever is pulled over to the other side of its neutral position. In this way the plate clutch is released, but the band brake is applied to the outside of the casings and holds it stationary. Motion is then taken through the sun and planet wheels to the teeth on the interior of the drum, which is keyed to the propeller shaft.

This gear is built without any lower links, which are troublesome to get at, during installation and for repairs. Stop links securely hold the gear in the positions in which it is set.

A totally-enclosed type has been constructed for use where oil and water tightness are requirements. The casing is made in two parts, and the top half can be quickly removed for the purpose of maintaining the oil level and making adjustments. An adjustable double ball bearing of the thrust type is fitted and the main shafts are provided with bronze bearings to ensure water and oil tightness.

A congress, at which interesting papers relating to boating were read, was held in connection with the exhibition. The programme included papers on "Hydraulic Propulsion," by D. V. Hotchkiss; "Dinghy Racing," by Leslie Lewis; "Cruisers of under 5 Tons," by Harrison Butler; "The Rule of the Road in Racing," by Major Heckstall-Smith; "Model Yachting," by W. J. Daniels; "Notes on Propellers, Shafts and Installation Fittings," by Major A. L. Young; "Water Resisting Varnishes," by J. W. Butcher; "Racing and its Effect on Design," by H. W. Hutchinson; "Small Cruiser Yachts," by E. G. Martin; and "How to Make a One-Design Class Successful," by W. S. Moore.

The patronage the show received, the quality of the exhibits, and the interest taken in the papers read at the congress are good evidence of the correctness of the view that such an exhibition was wanted.

The divisions in the ranks of those who cater for the requirements of the boating public are matters that do not interest us, but we regret to see them, and we trust that all sides may soon come together again, and that the next show may represent the whole field of activity of our manufacturers both on the engineering and boat-building sides.

TESTING THE TENSILE STRENGTH OF GAS MANTLES.—At the Physical Society, Mr. J. T. Robin, of the Incandescent Mantle Works, Streatham, demonstrated on Friday, the 10th inst., his apparatus for testing the tensile strength of gas mantles. He pointed out that the mantle maker has no means of checking the quality of his article until the mantle is finished, but a final strength test was very desirable. For this purpose the mantle used to be vertically suspended on a rod which was then rocked up and down until the mantle gave way. In performing his own test Mr. Robin first burns the fibre with the aid of a small ring gas-burner which he passes over the suspended mantle; in the case of an inverted hemispherical mantle, the flame is passed up and down several times. The mantle is then suspended by its ring in the special apparatus, which is a vertical cylinder, filled with water, in which a tubular float moves up and down; the float is gradually charged with water, until the weight of this water breaks the mantle, the lower part of which is attached to the upper end of the float. The attachment is effected by melting a little coloured wax in a tray, mounted on the cylinder, lowering the mantle a little so that it dips into the wax, and then allowing a few minutes for the solidification of the wax. Although the mineral skeleton of a mantle (consisting of the nitrates or oxides of thoria and a little ceria) weighs only about 1 gramme, a good mantle will sustain a weight of 70 grammes and even of 250 times its own weight, whilst a weak mantle may fail under a load of 30 grammes. In the Robin test the mantle generally breaks in a horizontal plane, near the supporting ring; the fracture of a badly-made mantle will be irregular. It is stated that the test is found to be instructive to the manufacturer of the mantles.

"THE EFFECT OF LOAD FACTOR ON POWER STATION COSTS."

To the Editor of Engineering.

Sir,—I was extremely interested in the leading article on the above subject published in your issue of November 3, as this is a matter which concerns all central station engineers.

It is quite true, as you state, and as I showed in an article published in *The Electrician* in 1905, that the total consumption of coal in a power station follows the "Willans" law, and therefore, that, within the capacity of any given plant, an increase in the total output will result in a reduction in the coal per unit generated, even if the load factor is decreased.

You do not, however, in your article make it clear that, if further plant is installed the initial consumption (*i.e.*, the losses) is increased. When this happens the average coal per unit may be increased, notwithstanding an increase in output.

In the course of your article you say "the great aim of the central station manager should be to increase his output regardless of load factor so long as he has plant to produce the electricity, or the money to buy it with."

Even if this statement is intended to apply only to the question of the reduction of coal consumption, it is for the reason shown in the previous paragraph, not sound, while it takes no account of the effect of capital charges.

The last paragraph of your article appears to be an argument against the use of what is known as a two-part tariff, where the charge is in some such form as:

Pound X per kilowatt of consumers' maximum demand, plus Y pence per kilowatt-hour.

Such a tariff is not necessary if the load factor of any consumer, or class of consumer, is known accurately, as the effect of capital and other standing charges can be calculated and allowed for in the price quoted, but where the load factor is not known, or where a consumer can increase his load factor, such a tariff has been proved to be of the utmost value.

For instance the owners of a shop, using electricity for lighting, would hesitate to leave their lights on in the windows after business hours, if the electricity were charged on a flat rate based on the average load factor of such supplies, but if the extra units required for such use could be obtained at a small charge to cover running costs, the consumer would have every incentive to use electricity for this, and other similar purposes, with a consequent improvement in load factor and increase in total consumption.

In another paragraph you compare unfavourably the results of electricity supply in England and abroad, and quote Shanghai as an example.

Such comparisons are generally quite unfair as conditions at home and abroad are entirely different, notably as regards competition with gas which is frequently non-existent abroad.

In the case of Shanghai and most other undertakings where large outputs have been built up, the business has been secured by a policy of encouraging business of high load factor by the offer of tariffs designed to that end.

The special rates quoted at Shanghai have caused the Japanese to establish factories in the area, where they can also obtain cheap labour, and this is the cause of the wonderful growth of the undertaking. The engineer and manager, Mr. Aldridge, deserves every credit for his imagination and foresight in appreciating the possibilities of the situation, but undoubtedly, when considering this matter, he had load factor constantly in his mind.

It would be unfair to blame undertakings at home because they cannot achieve similar results under totally different conditions.

I agree with you that there are enormous developments still possible in the supply of electricity in this country, especially for domestic purposes, possibilities which perhaps have not been fully realised in the past, but I am quite certain that such development can only take place by the more general use of two-part tariffs.

I am, Sir, yours faithfully,
W. A. Vignoles.

Corporation Electricity Works, Grimsby,
November 21, 1922.

[Col. Vignoles' statement that "within the capacity of any given plant an increase in the total output will result in a reduction in the coal per unit, *even if the load factor is decreased*," is precisely the contention underlying our article. We think the effect mentioned in his third paragraph is quite negligible in practice. The reference to tariffs was an incidental one in our article. The subject, however, lends itself to considerable discussion and it would be difficult to do proper justice in a brief note to the idea underlying our reference. We will deal with the points raised by Col. Vignoles and Mr. Beauchamp on a later occasion.—Ed. E.]

To the Editor of Engineering.

Sir,—I have read with considerable interest the editorial on the above subject, in your issue of November 3.

Personally, I had always assumed that the load factor of any plant was the ratio of the average load over any specified period, to the normal full-load capacity, in which case, a poor load factor would mean high operating costs per unit, and *vice versa*.

Might I suggest that it is just such a misunderstanding regarding the definition of "load factor," rather than an ignorance of facts, which is responsible for the belief that the load factor has a direct influence on operating costs.

At the same time, it would seem to me that the above definition is the more rational since it gives a direct indication both of operating costs, and the overhead charges to be carried per unit.

In fact, have you not assumed this definition, or, what amounts to the same thing, a constant peak load, in estimating the effect of load factor on capital charges? Does the same argument not apply here as in the case of operating costs, namely, that the proportion of the charges to be carried per unit depends on the total units generated per annum, irrespective of the ratio of average load to peak load?

It would seem that this latter ratio is of little practical value, whereas the ratio of average load to normal full-load capacity is of vital interest, especially when comparing the results of different power stations

I remain, Sir, yours faithfully,
W. Lennox Coats.

19, Westbourne-road, Urmston, Manchester,
November 19, 1922.

[In order to avoid any possible misconception on the subject we defined "load factor" explicitly in our article as "the ratio which the average demand for a year bears to the maximum demand during the same period." This, we believe, is the sense in which the term is understood amongst engineers, and in which it has been used for many years by our contemporary, *The Electrical Times*, in its periodical tables of power station results. Load factor, so defined is a perfectly definite quantity, expressing the nature of the load, and having no concern at all with the equipment of the station. The definition our correspondent suggests involves the "normal full-load capacity" of the plant, which has no satisfactory meaning, as it raises the question as to how existing obsolete plant or reserve plant should be dealt with, and whether the normal full load of a machine is its maximum continuous load, or its most efficient load. If our correspondent will read the article again, he will see that we have never used or implied any meaning of the term load-factor other than as expressed in the definition quoted above.—Ed. E.]

To the Editor of Engineering.

Sir,—Your leader on page 557 of your issue of November 3 omits many considerations of the first importance to the engineer who has to run a power plant, make money out of it and yet be able to let it expand indefinitely without becoming less remunerative. As output increases plant capacity becomes filled up—kilowatt by kilowatt—hastening the day when new plant must be bought; but that new plant is not bought kilowatt by kilowatt, but in large parcels, sufficient perhaps for three or five years' growth, and each new parcel of plant adds a heavy burden to costs until it becomes perhaps 50 per cent. occupied.

In a business the main feature of which is costly and permanent investment before any commodity can be delivered, it is quite sound policy to offer the consumer a chance of sharing in the fixed charges which he entails. Tariffs which encourage consumption high relatively to rate of demand, and discourage the contrary condition, have the double advantage that they take into consideration "value of service to user," and also help to reduce the whole scale of costs and charges, so sharing the benefit of development with all users.

It is futile to draw comparisons with the retailing of a simple article, which can be made at a steady rate and stocked, sold at any rate or time and even moved from one market to another. The supplier of electricity is "linked" to his customers, cannot readily change his market or method of working, and must, even if he does not declare it, at least base his charges on something more scientific than the mere averaging which suffices in many businesses.

Consider a by no means extreme case: A consumer of electricity wants 10 gallons of boiling water at a certain hour of the day. He can employ an electric geyser taking 12 kw. for half an hour, or he can use an electric heat storage tank taking 0·6 kw. for 10 hours. The units are the same in each case, but in the latter the call upon plant and cables is only one-twentieth of the former.

The value of electricity to the user is so great that it is more important for it to be "abundant" (*i.e.*, within the reach of all) than for it to be "cheap"—if it is too cheap or not sold on such terms that increasing demands will be increasingly remunerative to the supplier, then the system of supply will not be capable of healthy and rapid growth, the steady inflow of capital will be discouraged, and distribution facilities must remain curtailed.

Yours faithfully,
J. W. Beauchamp, Director and Secretary.
The British Electrical Development Association, Inc.
15, Savoy-street, Strand, London, W.C. 2.
November 20, 1922.

"DOUBLE REDUCTION GEARS FOR TURBINES."

To the Editor of Engineering.

Sir,—I have read with interest the letter which appeared in your issue of November 10, page 586, over the signature of Mr. R. R. Gray Chisholm. Steel-makers have come to the conclusion that the failures of pinion teeth are due to fatigue, this decision being the result of scientific investigation of steel which had failed in service.

The statement contained in the third last paragraph of Mr. Gray Chisholm's letter is one often expressed by engineers; can he publish any evidence in support of it? Might I suggest to Mr. Gray Chisholm that he will help considerably to the solution of the problem if he will now publish the actual stresses to which pinions are subjected during their work at sea.

Yours faithfully,
T. M. Service.

Parkhead Forge Rolling Mills and Steel Works,
Glasgow, November 21, 1922.

NOTES FROM SOUTH YORKSHIRE.

Sheffield, Wednesday.

Iron and Steel.—Signs of improvement are more apparent now that the disturbance created by the General Election has been removed. The state of order books at representative steel-making and engineering firms gives hope of more active conditions in the early future. The proportion of inquiries yielding solid business tends to increase. Basic steel shows a steadily rising output in the face of renewed imports from Belgium and Germany following the latest depreciation in Continental exchanges. Extra shifts are being worked to expedite deliveries, and arrangements are being made to put additional plant into commission. A rather more hopeful tone prevails in special steels. That makers are better placed than a month ago is indicated by the increased deliveries of special low phosphorus iron coming into the South Yorkshire district from West Coast producers. Another good sign is the expansion in business in steel scrap. Furnace masters are anxious to augment reserves against increasing commitments, though as a result of recent heavy purchases made by Continental consumers, forward deliveries can be arranged only at enhanced rates. Railway steel is a better market, and the axle, tyre and spring departments are benefiting from wagon orders placed by South Yorkshire and Derbyshire collieries. A substantial tonnage of implement part and tools is going away to Canada and Australia. Some of America's former customers have taken fright at the high tariffs operating in the United States and are inquiring for supplies from local sources. Steady pressure is being placed upon railway amalgamations to give out their orders for electrical requirements and rolling-stock at the earliest possible moment so as to strengthen the forward movement and further reduce unemployment. Forges and foundries are doing an improved business with shipbuilders on the Tyne and the Clyde. The lighter sections would occupy a much stronger position if the business in hand yielded a reasonable margin of profit. In the absence of a definite understanding between manufacturers, price-cutting has reached a remarkable degree of severity. So keen is the competition for the latest contracts that much of the work will show a loss. One of the most active mediums is mining implements. Australia, Scandinavia, and South Africa are taking a fair tonnage of implements and machinery parts. Rock drills and steam shovels are wanted for Northern Ontario. Stainless steel is in heavy demand in the cutlery trade.

South Yorkshire Coal Trade.—Mixed conditions prevail in the market for best steam hards. Exports are quieter, with a disposition on the part of sellers to accept lower rates; but on home industrial account a healthy demand calls for increased tonnages. Collieries generally are free from stocks. Better qualities of cobbles, nuts, and slacks are moving more freely, though rising surpluses of inferior grades impede work at the pits. Furnace coke is quieter, but foundry sorts are in good demand. House coal inquiries are yielding some nice orders for better qualities, but collieries find it difficult to dispose of the surplus of inferior grades. Quotations:—Best branch handpicked, 32*s.* 6*d.* to 34*s.* 6*d.*; Barnsley best Silkstone, 28*s.* to 30*s.*; Derbyshire best brights, 24*s.* to 26*s.*; Derbyshire best house, 21*s.* 6*d.* to 22*s.* 6*d.*; Derbyshire best large nuts, 19*s.* 6*d.* to 22*s.* 6*d.*; Derbyshire best small nuts, 15*s.* to 16*s.* 6*d.*; Yorkshire hards, 20*s.* to 21*s.*; Derbyshire hards, 19*s.* to 20*s.* 6*d.*; rough slacks, 8*s.* 6*d.* to 10*s.* 6*d.*; nutty slacks, 7*s.* 6*d.* to 8*s.* 6*d.*; smalls, 3*s.* to 5*s.*

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

Middlesbrough, Wednesday.

The Cleveland Iron Trade.—Some customers are endeavouring to get down prices of Cleveland pig-iron, and as a matter of fact business has been put through at a little below the recognised market rates that have ruled for some time past, but many makers are very loath to make price concessions, and indeed values can hardly be said to be quotably lowered. Several producers are booked well ahead. No. 1 and siliceous sort remain at 97*s.* 6*d.*; No. 3 G.M.B. at 92*s.* 6*d.*; No. 4 foundry, 90*s.*; No. 4 forge, 85*s.*; and mottled and white, 81*s.* 6*d.* to 82*s.* 6*d.*—all f.o.t. and f.o.b.

Hematite.—A healthy state of affairs exists in the East Coast hematite branch. Supply is hardly equal to requirements, and there is a probability of output being increased in the near future. For home consumption, and for despatch to destinations abroad, Nos. 1, 2 and 3 are 93*s.* to 93*s.* 6*d.*, and No. 1 is put at a shilling above mixed Nos.

Blast Furnaces in Operation.—The number of blast furnaces blowing is steadily increasing. There are now 33 in operation in this district. Of these 9 are producing Cleveland pig-iron, 12 are making hematite, and 12 are manufacturing other kinds of iron.

Foreign Ore.—There has been a little more doing in foreign ore lately, but sales are still slow, and prices are weak. Sellers ask 22*s.* 6*d.* c.i.f. Tees for best rubio, but consumers will not pay that figure, and report they can purchase first-rate Mediterranean ore at 20*s.* c.i.f.

Blast-Furnace Coke.—Local users of blast-furnace coke are very disinclined to pay more than 28*s.* 9*d.* for average Durhams delivered, and report they can purchase at that figure, but several sellers hold out for a rather higher price.

Manufactured Iron and Steel.—A good deal more business is passing in both manufactured iron and steel. Producers report quite a lot of inquiries circulating, and regard prospects as better than for some time past. Orders for ship plates, and other shipbuilding requisites

are now being given out, fairly substantial contracts for steel rails are understood to have been made, and constructional material is being bought on a rather good scale. Common iron bars are 10*l.* 10*s.*; iron rivets, 11*l.*; steel bars, 9*l.*; steel billets, 7*l.* 5*s.* to 8*l.* 5*s.*, according to quality; steel boiler plates, 12*l.* 10*s.*; steel ship, bridge and tank plates, 9*l.* to 9*l.* 10*s.*; steel angles, 8*l.* 15*s.*; steel joists, 9*l.* 10*s.*; tees, 10*l.*; heavy sections of steel rails, 9*l.* to 9*l.* 5*s.*; fish plates, 14*l.* 10*s.*; black sheets, 12*l.*; and galvanised corrugated sheets, 17*l.* 10*s.*

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scottish Steel Trade.—The turn of trade for the better is not yet in sight and steel makers are grumbling considerably at the slowness of affairs. On all sides there is quite a dearth of specifications, and fresh business is of such small tonnage that it is only managing to take the place of orders executed, and thus keep running the minimum amount of plant now in operation. Ship plates are in poor demand as the position in the shipyards has not changed, and sectional material has also struck a dull patch at present. Makers of black steel sheets are just the turn better but the improvement is really infinitesimal. Local consumers have been placing a few more orders and the export trade with the Far East has been steadily improving. The foreign trade in general is slightly better, although it is only a shadow of what we are accustomed to receive. Prices keep steady and are quoted as follow, but where a reasonably good line is on offer special consideration is given:—Boiler plates, 12*l.* 10*s.* per ton; ship plates, 9*l.* per ton; sections, 8*l.* 15*s.* per ton; and sheets, $\frac{7}{8}$ in. to $\frac{1}{4}$ in., 10*l.* 10*s.* per ton, all delivered Glasgow stations.

Malleable Iron Trade.—Movement in the malleable iron trade in the West of Scotland is far from encouraging at the present time and no improvement of any kind can be reported. Buyers are most unwilling to commit themselves beyond their actual needs of the moment, with the result that the works are only kept going in a half-hearted fashion. Specifications are coming in very slowly, but occasionally there are one or two quite good inquiries. There has been no change in prices, which are based on 10*l.* 10*s.* per ton, delivered Glasgow, for "crown" bars.

Scottish Pig-Iron Trade.—The Scottish pig-iron trade, which has for some time past been doing fairly well on account of the American demand for foundry sorts, shows signs of an approaching dullness. This, however, may be nullified by the prospects of an improvement in the home demand which is freely anticipated here. One point worth noting is that several more furnaces are now in the process of being rekindled. Hematite iron continues to be in very poor demand. Quotations are again easier, and to-day's rates are as follow:—Hematite, 5*l.* 7*s.* 6*d.* per ton, delivered at the steel works; foundry iron, No. 1, 5*l.* per ton, and No. 3, 4*l.* 15*s.* per ton, both on trucks at makers' yards.

Pig-Iron Shipments.—The shipments of Scottish pig-iron from Glasgow Harbour during the week ending Saturday, November 18, show a decided decline, as the total was only 1,437 tons. Of that amount 1,321 tons went abroad and 116 tons coastwise. For the previous week the total was 4,583 tons, but for the corresponding week a year ago the amount was just 416 tons. The total shipments for the year to date are now 88,853 tons, of which 81,243 tons have gone foreign.

Shipbuilding.—Orders for new vessels continue to be booked by Scottish shipbuilders, but the process is very slow, although it is tending in the right direction. The latest contracts to be reported are two 6,000-ton steamers to be built for the Holt Line, Liverpool, by the Caledon Shipbuilding and Engineering Company, Limited, Dundee. An order for a coasting vessel has also been secured by the same builders. The Burntisland Shipbuilding Company have also received orders to build a steamer of 4,300 tons for Bristol Channel owners, as well as two smaller vessels, each of 1,000 tons, for British owners.

Institution of Engineers and Shipbuilders in Scotland.—A highly interesting paper, entitled "Launch Velocities and Drags," was read last night by Professor Percy A. Hillhouse, D.Sc., of Glasgow University, at a meeting of the Institution of Engineers and Shipbuilders in Scotland, in the hall, Elmbank-crescent, Glasgow. The president, Mr. Harold E. Yarrow, C.B.E., was in the chair. Professor Hillhouse referred to the launching of a ship into restricted waters, which was, he said, a problem of peculiar interest to shipbuilders on the upper reaches of the Clyde. The river at Govan had a breadth of about 450 ft., and in order to obtain launching room the centre lines of the building berths had to be laid at an angle to the line of the waterway, and this had made possible the launching of the battle-cruiser Renown, which was nearly 800 ft. in length, and was the longest vessel yet floated into the upper reaches of the river. Such launches had necessitated the use of "drags," and Professor Hillhouse enlarged on this side of the question.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Coal Trade.—A congestion of shipping at the docks and delay in the arrival of coal, and consequent loss of time in returning empty wagons to the pits, has disorganised the coal trade and created a number of difficulties. These difficulties have been aggravated by the decision of the Cardiff, Penarth and Barry coal trimmers not to wait more than 2 hours in any shift unless payment is made at the rate of 2*s.* per man per hour. The employers have refused to pay waiting time, contending that this matter was taken into consideration in the fixing of the national tariff, and they threaten to reopen the question of revising the tariff if the men persist in their attitude. The men contend that they could deal with more coal if the organisation was improved and waiting time reduced, and point out that in one case only 10 hours was actually worked in four shifts of 32 hours, the remainder of the time being occupied in waiting for coal or tippers. In another instance they allege that in 54 working hours there was a total loss of 26½ hours in waiting time. During the past week there have been from 20 to 30 vessels waiting for loading berths each day, and in a number of cases collieries have experienced much difficulty in working without temporary stoppages because of a shortage of empty trucks and lack of clearance of loaded wagons. To-day, however, the general position showed some improvement. Orders which were cancelled or postponed in consequence of the fall in the value of the French and Belgian francs have been renewed on a recovery in the exchanges, and a fair amount of quiet buying has also taken place. In fact, some colliery companies are stated to be out of the market for the rest of the year. Generally best Admiralty large coal is round 27*s.* 9*d.*, seconds 27*s.*, best dry large 28*s.*, and ordinaries 27*s.*, with the leading Monmouthshires from 25*s.* to 26*s.* Smalls of all grades continue in excessive supply, with prices erratic from 9*s.* to 16*s.*, according to quality. Exports of coal as cargo last week amounted to 553,000 tons, or 17,000 tons more than in the previous week. Of the total, 188,900 tons went to France, 82,700 tons to Italy, 75,000 tons to South America, 29,400 tons to Spain, 11,600 tons to Portugal, 9,200 tons to Greece, 66,400 tons to British coaling depots, 14,500 tons to the United States, 5,100 tons to Canada and 100,000 tons to other countries.

Iron and Steel Trades.—There is a good all-round demand for tin plates, and prices are steady at 16*s.* 6*d.* to 16*s.* 9*d.* There was a further improvement in the volume of the iron and steel goods export trade last week, the total of 17,000 tons comparing with 13,950 tons in the previous six days. Black plate shipments amounted to 2,301 tons compared with 2,056 tons; tin plates to 7,945 tons against 7,231 tons; galvanised sheets to 2,613 tons against 771 tons; and iron and steel, which includes steel bars, sheets, tubes and railway material, to 4,223 tons against 3,892 tons.

SWITCH GEAR AND "SAFETY FIRST."—Messrs. Brook, Hirst and Co., Limited, Northgate Electrical Works, Chester, announce that they have now a comparatively complete collection of lantern slides illustrating their "safety first" motor starting panels, which they will be pleased to lend to any intending lecturers, together with appropriate explanatory notes.

THE INSTITUTION OF PRODUCTION ENGINEERS.—We have received the first volume of the proceedings of this Institution, which was formed, on February 26 last, to promote the science and practice, and raise the status of engineering as applied to production. It contains papers and discussions thereon dealing with ball and roller bearing manufacture, the production of spur gears, the efficient production of automobile bodies, electricity in modern engineering works, etc. It is admirably printed and illustrated. The book gives also a list of the members and the objects and rules of the Institution. It contains 422 pages of interesting matter, to which a somewhat detailed index would prove a valuable addition. We suggest the addtion of such an index be considered in future issues.

THE INSTITUTE OF METALS.—The Institute announce that their name and subject index, covering Vols. I to XXV, is now available at the price of 25*s.* net (25*s.* 9*d.* post free). This index will be found most useful by manufacturers and users of non-ferrous metals and alloys, and by all who are engaged in research and teaching. The Institute also call attention to the very favourable terms they are offering to student members. These pay an entrance fee of one guinea only, their annual subscription is one guinea also, and they are transferred to full membership without payment of any further entrance fee, upon reaching the age of twenty-five. They have all the privileges of ordinary members except voting at meetings. The next election of students and ordinary members takes place on December 14.

THE JUBILEE OF "THE ELECTRICAL REVIEW."—It is a pleasure to offer congratulations to our contemporary, *The Electrical Review*, on the completion of fifty years of active existence. The first number appeared under the title of *The Telegraph Journal* on November 15, 1872. The publication was at that time a monthly. With the issue of January 15, 1873, the name was changed to *The Telegraph Journal and Electrical Review*, while on May 14 of that year it became a fortnightly publication. The paper became the weekly which is now so familiar on January 7, 1882, and the words "Telegraph Journal" were dropped entirely from the name in 1891. In celebration of its fifty years of publication the issue of the journal of last Friday was of a special and enlarged kind, and contained messages of congratulation and reviews of progress by a large number of eminent electrical engineers. We should like to add our tribute to the ability with which our contemporary has been conducted over this long period, and the honesty of purpose for which it has always been distinguished.

NOTICES OF MEETINGS.

THE INSTITUTION OF MECHANICAL ENGINEERS.—Friday, November 24, at 6 p.m., at Storey's Gate, St. James's Park, S.W. 1. Extra General Meeting. Adjourned discussion on "Air Compressors," by Mr. William Reavell, Member of Council. Friday, December 1, at 6 p.m. Dr. T. E. Stanton, C.B.E., F.R.S. (Member of Council), will deliver the Thomas Hawksley Lecture, the subject being "Some Recent Researches on Lubrication." The Lecture will be repeated in Manchester, December 7; Leeds, December 8; and Birmingham, December 13.

THE BRADFORD ENGINEERING SOCIETY.—Monday, November 27, at 7.30 p.m., in the Hall of the Bradford Technical College. Lecture by Mr. J. S. Atkinson (of London), on "Some Recent Developments of Powdered Coal Firing."

THE ROYAL SOCIETY OF ARTS.—Monday, November 27, at 8 p.m. Cantor Lecture, "Brown Coals and Lignites," by Mr. William Arthur Bone, D.Sc., Ph.D., F.R.S., Professor of Chemical Technology, Imperial College of Science and Technology, South Kensington. (Lecture I.) Wednesday, November 29, at 8 p.m. Ordinary Meeting. "The Hot-Wire Microphone and its Applications to the Problems of Sound," by Major W. S. Tucker, R.E., D.Sc., Signals Experimental Establishment, Woolwich. Admiral-of-the-Fleet Sir Henry B. Jackson, G.C.B., K.C.V.O., D.Sc., F.R.S., will preside.

THE INSTITUTION OF CIVIL ENGINEERS.—Tuesday, November 28, at 6 p.m. Continuation of the discussion on Mr. E. O. Forster Brown's paper on "Underground Waters in the Kent Coalfields."

THE JUNIOR INSTITUTION OF ENGINEERS: NORTH-EASTERN SECTION.—Tuesday, November 28, at 7.15 p.m., in Armstrong College, Newcastle, Mr. E. F. Oakford will present a paper entitled "Notes on Iron Foundry Practice."

THE NORTHAMPTON ENGINEERING COLLEGE ENGINEERING SOCIETY.—Thursday, November 30, at 5.30 p.m. Paper on "Cinematography," by Mr. F. L. Best.

THE INSTITUTION OF ELECTRICAL ENGINEERS.—Thursday, November 30, at 6 p.m., "Domestic Load Building: A Few Suggestions upon Propaganda Work," by Mr. W. A. Gillott, Associate Member.

THE INSTITUTION OF LOCOMOTIVE ENGINEERS (LONDON): MANCHESTER CENTRE.—Friday, December 1, at 7 p.m., at the College of Technology, Manchester, when a discussion on "Some Details of Locomotive Practice" will be opened by Mr. K. W. Smith, Member.

THE JUNIOR INSTITUTION OF ENGINEERS.—Friday, December 1, at 7.30 p.m., at 39, Victoria-street. Lecturette, "Machines Used in Magnetic Separation," by Mr. H. G. Brown (Member).

THE INSTITUTE OF INDUSTRIAL ADMINISTRATION.—Tuesday, December 12, at 8 p.m., at the Great Hall, London School of Economics, Houghton-street, Aldwych. A Lecture on "Standardisation of Repairs in Relation to Industrial Economy" will be delivered by Mr. Richard Twelvetrees, A.M.I.Mech.E., followed by discussion. Chairman, Mr. H. M. A. Tuckwell, M.I.Mech.E.

AMERICAN MARINE ENGINES FOR GERMANY.—We read in *The Iron Age*, New York, that American marine engines recovered from wooden hulls built for service during the war are now to be shipped to Germany and installed in steel hulls built there, according to a statement from a salvage company in Portland, Oregon, which is scrapping the wooden ships. There are 162 triple-expansion engines, of 1,400 h.p. each, involved in the proposed deal, which would provide the rapidly-growing German fleet of freight ships with motive power at less cost and in less time than would be needed to build new engines.

INSTITUTION OF NAVAL ARCHITECTS.—The following scholarships will be offered for competition in 1923, in connection with the Institution of Naval Architects: *Naval Architecture*: Martell (130*l.* per annum); Hawthorn-Leslie (150*l.* per annum); Vickers (150*l.* per annum); John Samuel White (100*l.* per annum); Denny (75*l.* per annum). *Marine Engineering*: Richardson Westgarth (150*l.* per annum); Denny (75*l.* per annum). All these scholarships are open to British apprentices or students and are tenable for three years at the following educational establishments: Glasgow University, Durham University (Armstrong College), Liverpool University, Royal Naval College (Greenwich), and the City and Guilds (Engineering) College, London. Full particulars may be obtained from The Secretary, Institution of Naval Architects, 5, Adelphi-terrace, W.C. 2.

THE LIBRARY OF THE ROYAL AERONAUTICAL SOCIETY.—The Council of the Royal Aeronautical Society announces that, through the generosity of the Trustees of the Carnegie United Kingdom Trust, it has been able to arrange for the purchase of a large collection of valuable historical books on aeronautics. The society's library will now form a complete collection of all important works on aeronautics from the seventeenth century down to the present day. At the request of the Carnegie Trustees, the council has agreed to make the books in the society's library available for any student in the British Isles through the medium of the Central Library for Students, 9, Galen-place, London, W.C. 1. By receiving permission to use the Royal Aeronautical Society's library, the Central Library for Students will be spared the necessity of forming a special section devoted to aeronautics.

THE PARIS WATER SUPPLY.

(*For Description, see Page* 639.)

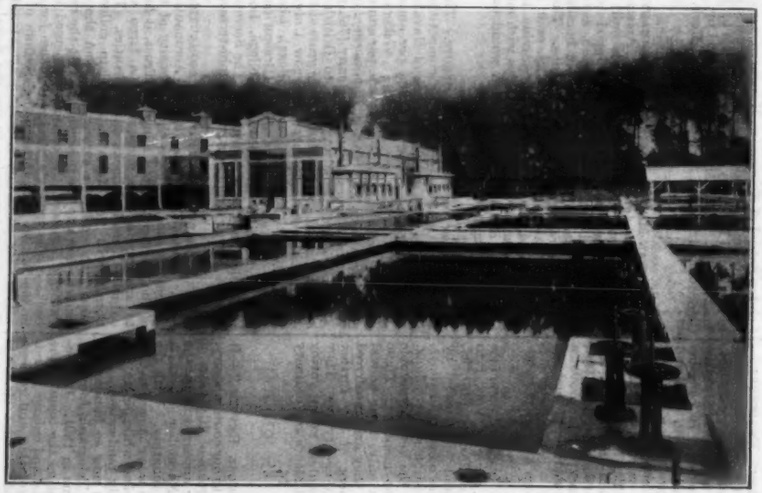


FIG. 15. FILTER-BEDS AND STERILISING INSTALLATION.

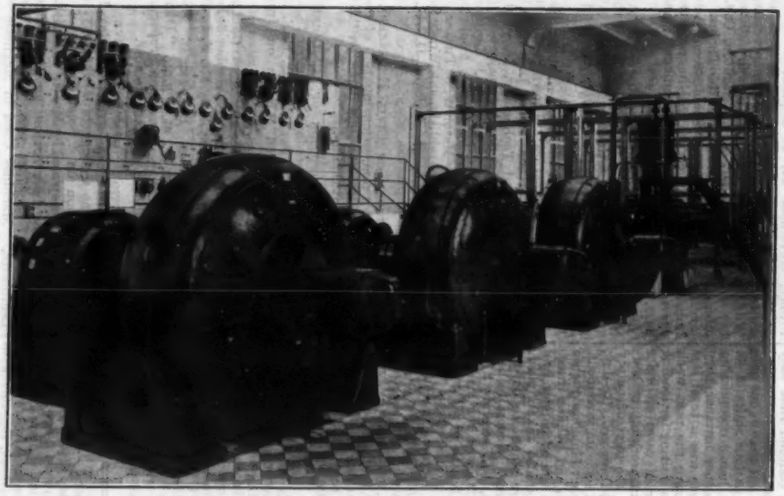


FIG. 17. MOTOR GENERATOR SETS.

FIG. 16. STERILISING PLANT.

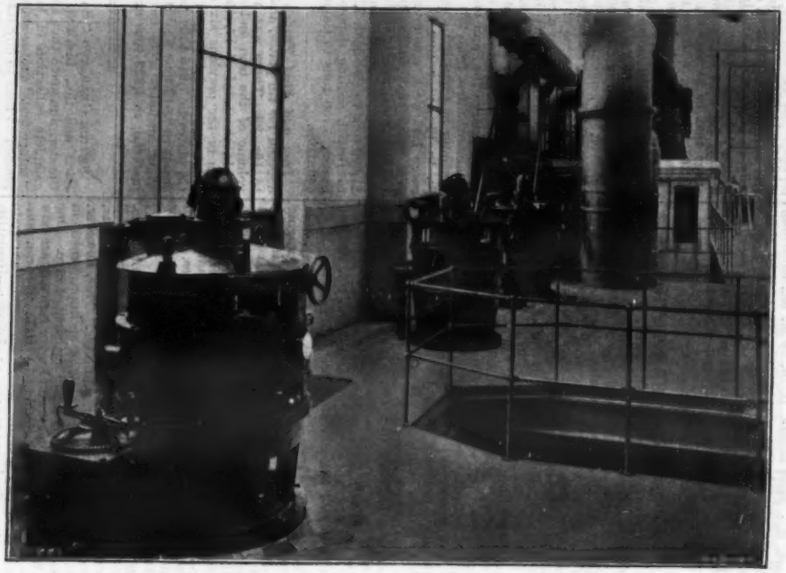


FIG. 18. ELECTRICALLY-DRIVEN PUMPS.

THE SOAKING PIT BUILDING AT THE MOSSEND STEEL WORKS.

(*For Description, see Page 641.*)

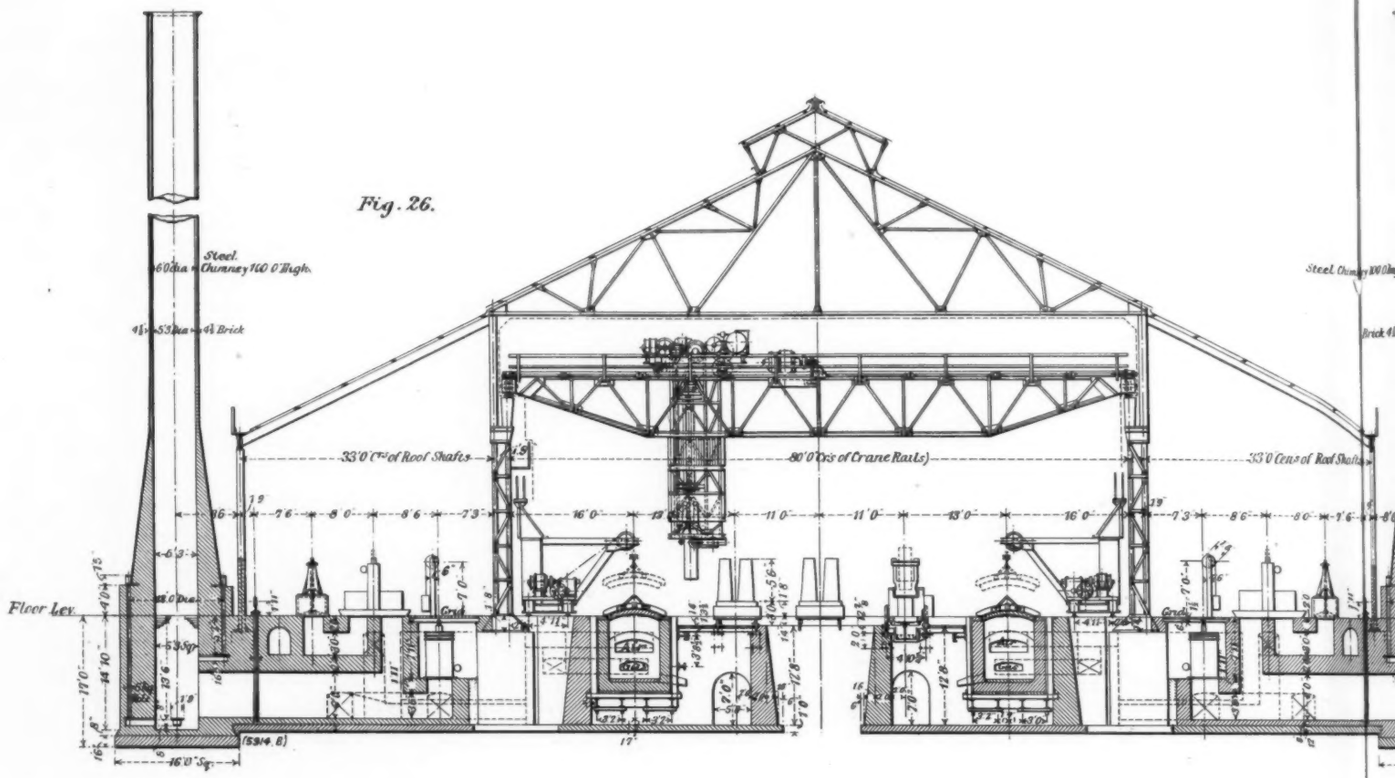
FIG. 25.

(*To face page* 642.)

THE MOSSEND STEEL WORKS AND ROLLING MILLS OF

(For Description see P

Fig. 26.



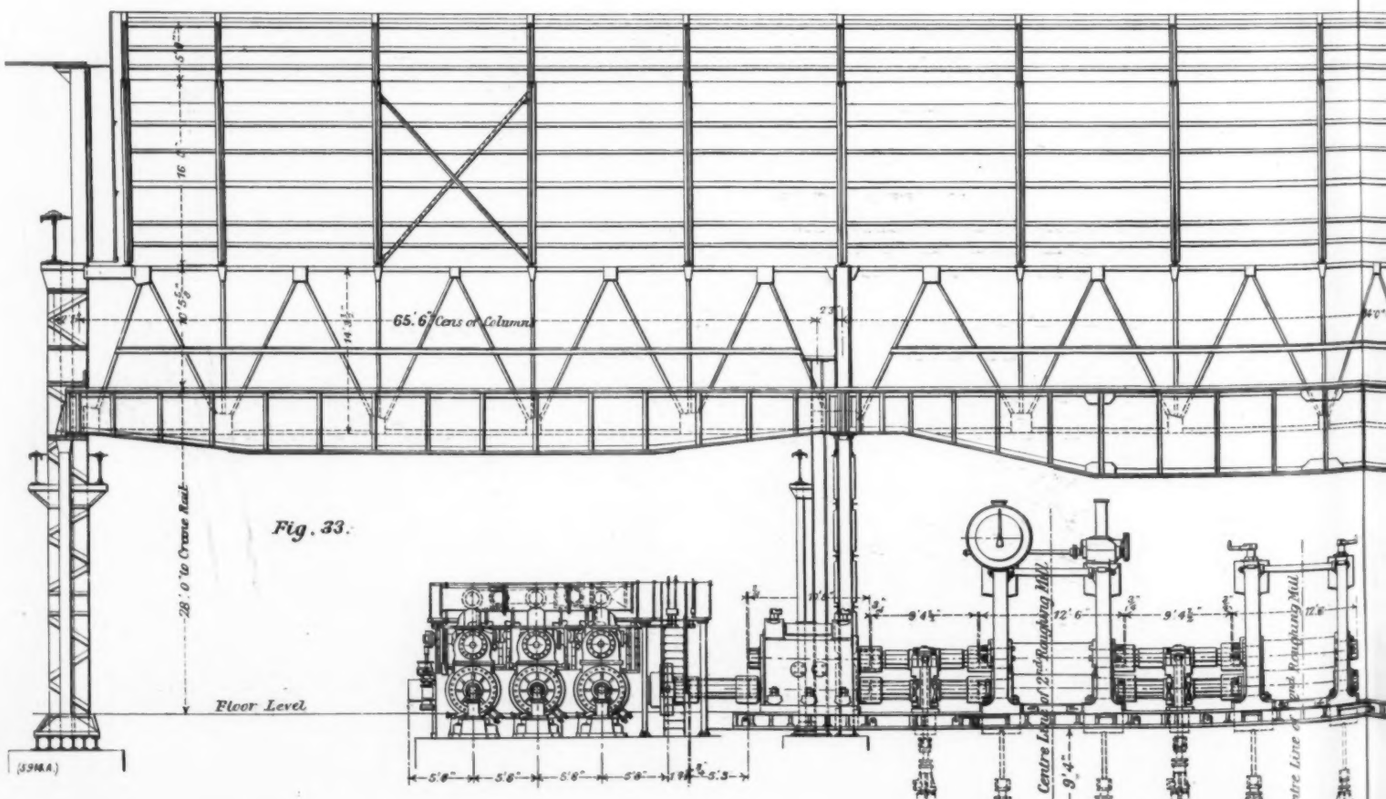
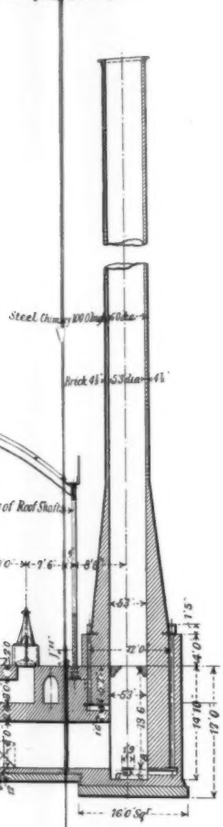


Fig. 33.

LS OF MESSRS. WILLIAM BEARDMORE AND CO., LIMITED.

(Description see Page 641.)



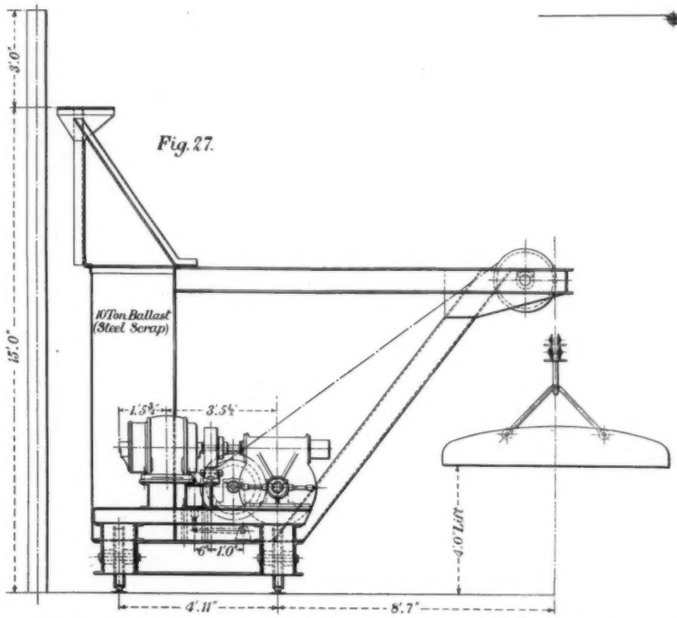


Fig. 27.

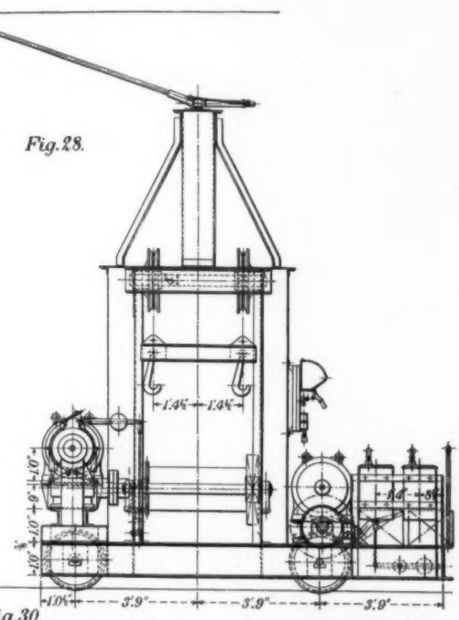


Fig. 28.

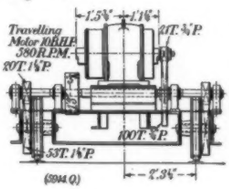


Fig. 29.

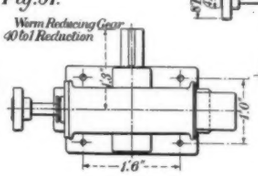


Fig. 31.

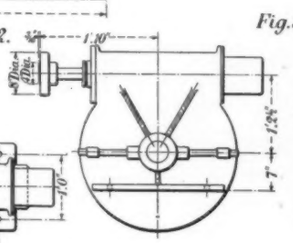


Fig. 32.

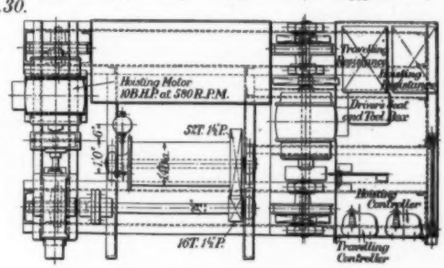
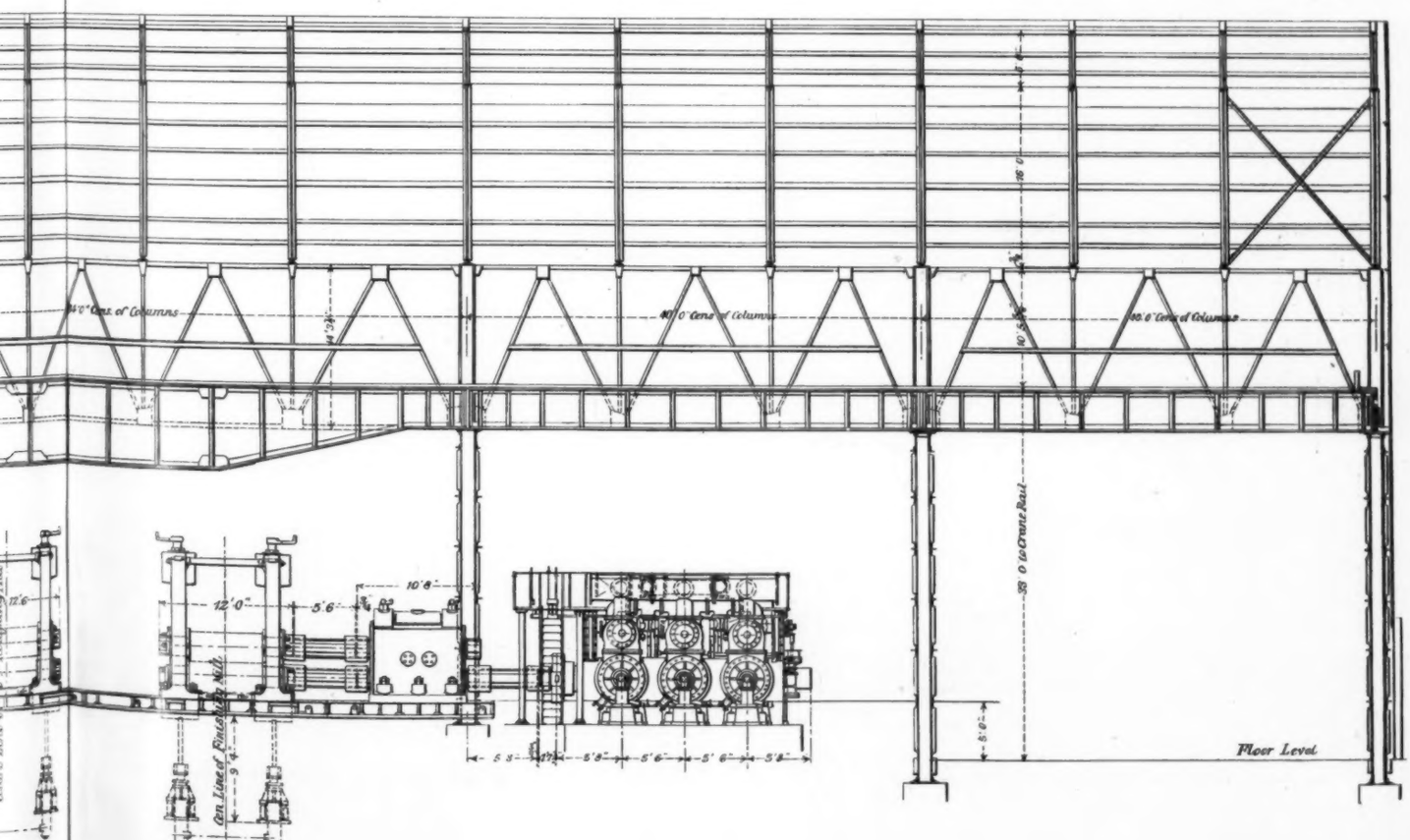


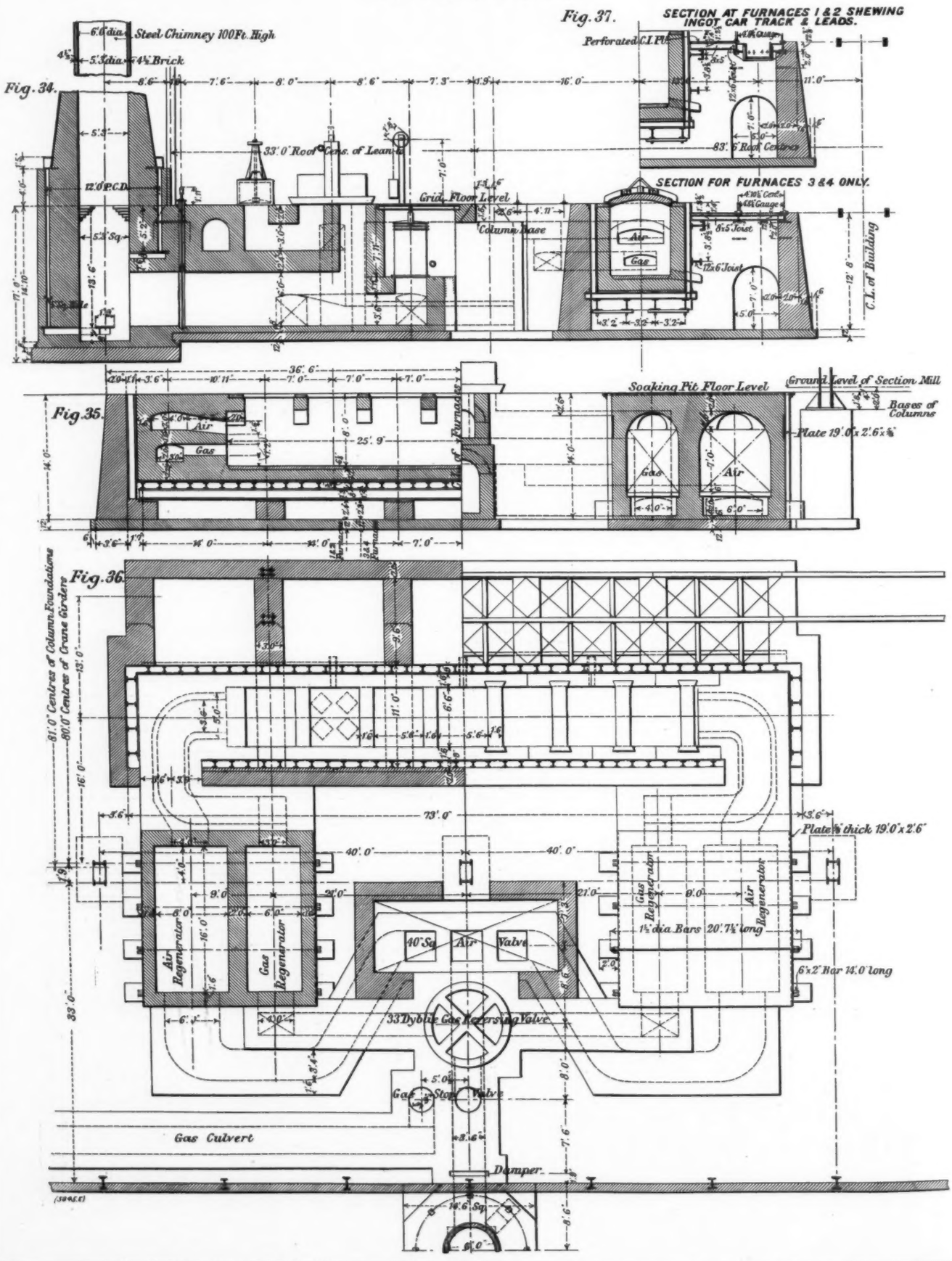
Fig. 30.



THE INGOT SOAKING PITS AT THE MOSSEND STEEL WORKS.

CONSTRUCTED BY MESSRS. WILLIAM BEARDMORE AND CO., LIMITED, ENGINEERS, GLASGOW.

(For Description, see Page 641.)



(To face page 643.)

ENGINEERING.

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One Two-Page Plate and Two One-Page Plates.—THE MOSSEND STEEL WORKS AND ROLLING MILLS OF MESSRS. WILLIAM BEARDMORE AND CO., LIMITED.

ENGINEERING.

FRIDAY, NOVEMBER 24, 1922.

WHAT THE WORKERS WANT.

ALTHOUGH there is not at the moment any outward symptom of social or industrial unrest in this country, the comparative success at the recent General Election of a party whose avowed aim is to bring about drastic changes in our social and industrial system, shows that a large section of the population is far from content with conditions as they are. Contentment, as every philosopher knows, is a state of mind which depends very little, if at all, upon wealth or circumstance. Were it otherwise, all rich men would be happy and all poor men miserable, which certainly is not in accordance with everyday experience. The real source of contentment is not in possession, but in a consciousness of continual progress and a pleasurable anticipation of future achievement. There is, it is true, a certain indolent acquiescence in things as they are which passes for contentment among minds of a vegetative nature, but the average individual wants to see that he is making progress towards his ideals, and to feel that he can compare his condition to-day favourably with that of yesterday or of last year. If healthy contentment then lies in a state of successful striving, there follows the somewhat paradoxical conclusion that it connotes a certain amount of dissatisfaction with present circumstances, otherwise there would be no striving towards improvement and no pleasure in the amount of progress made.

Assuming these premises are correct, it is of very great importance to examine, not so much the oratorical demands of those who claim to express the desires of the industrial population, but rather the unformulated ideas and genuine aspirations, the force of which constitutes the real strength behind the so-called labour movement. No greater mistake can be made than to assume that the motives which actuate the manual worker are different in kind from those which determine the conduct of any other section of the population. Human nature, with its curious combination of selfishness and altruism is common to all, and its primary law, like that of Nature in general, is the self-preservation of the individual. The first concern of the latter, is therefore to secure for himself a continuous and increasing income, sufficient to provide for his own needs and those of his family. In endeavouring to obtain this without particular regard to the services he is rendering to the community in exchange for it, the manual worker is neither more nor less blameable than the Government employee who holds the same ideals, and who indeed has secured for himself the further privileges of permanency of employment and promotion by seniority independent of merit. But when the manual worker seeks to obtain an equally favoured position his demands at once arouse the employers instincts of self-preservation, for though Whitehall may be able to ignore sound economic principles, ordinary business cannot.

One of the commonly heard aspirations of the Labour Party is to bring about the nationalisation of industry. Among the so-called "intellectuals" of the party, most of whom are not, and never have been, working men in the ordinary sense of the word, nationalisation is a creed, based on some ideal conception of society which leaves out of account the factor of human nature. The desire for nationalisation, in so far as it really exists among genuine workmen, is not any academic wish for some theoretically perfect scheme of things. It is based on two ideas, both relevant to actual facts and therefore worth examining. The first ground for the desire, is a belief that employment by the Government would mean security of tenure, high wages and advancement by seniority rather than by ability and energy. Such conditions, however, which are possible so long as Government employees constitute only a small fraction of the population, could not possibly be maintained if the Government controlled all industry. There would then be no outside funds from which inefficiency could be subsidised, and as State management could never be so efficient as that of private employers trained in their business and dependent for their livelihood upon its success, the surplus available for the wage fund of the workers would be less than under present conditions. Somebody would have to bear the cost of inefficiency and incompetence of management, and the persons upon whom the burden would fall most heavily would be the manual workers who in Russia are now existing in a state of practical slavery. Furthermore, the labourer and manual worker would find themselves at the mercy of a tyranny from which there would be no appeal. To-day the Government can be invoked as an independent arbitrator to hold the scales fairly between employer and employed, but were the Government the sole employer it would be in the position both of judge and jury, too.

The second, and we think the most general, ground for desiring nationalisation of industry, is belief that somehow or other under the present system the worker is exploited. He has the idea that he is not getting the full benefit of his labour, and that the capitalists and shareholders who own the machinery and materials with which he works, are robbing him of all the rewards of his exertions except just enough to provide him with an uncomfortable existence. There is no doubt that such views are very prevalent among the industrial classes. They lie at the root of the "ca' canny" policy of restricting production, as this is merely the reaction of the natural man to the belief that he is working to enrich somebody else who has no right to profit by his labour. To deride such opinions, mistaken though they may be, is no argument. Nor can they be ignored, if industrial contentment and peace are to be secured. Thousands of workmen hold them honestly and strongly, and they are preached continually in workshops and lodges. But it has to be admitted even by the extremists that for industry to exist, capital, in the form of buildings and machinery must also exist, and as capital is nothing but the savings of thrifty men it will not be available unless some inducement to thrift, in the form of interest on savings, is available. The State can only acquire capital by taking it from the population, and if no capital could be held by private individuals, thrift would cease and the sources of taxation would dry up.

If, then, capital has to exist and to earn sufficient reward to make up for its losses and to renew its wastage, it does not really matter to the workmen whether it is owned by the State or by a private

employer. All that he is concerned with is whether he himself, as the user of it, is deriving a fair share of the profits accruing from his labour. This is the whole point, and it must be met by ensuring that the workman's share actually is a fair one and that he understands that it is so. Upon the possibility of this hangs the entire question of industrial peace and orderly economic progress. We have heard of several instances, during the present industrial depression, which bear out our contention. They have all been of the same kind, namely that a firm faced with the impossibility of securing orders at current rates, has placed the whole situation openly and fairly before its workmen, explaining the financial situation without reservation, and has found the men willing to accept lower rates in consideration of the shareholders making a corresponding sacrifice of their profits on a contract.

The first solution which suggests itself as a means of ensuring the worker receiving a fair proportion of the profits of a firm is some kind of co-partnership. Numerous schemes of this nature have been devised and introduced with more or less satisfactory results, but the slowness of growth of the movement and the numerous instances in which such schemes have been abandoned, do not promote confidence in co-partnership as generally understood, affording the ultimate solution to the industrial problem. In his presidential address to the Royal Statistical Society on November 21, Lord Emmott recounts the fate of 380 profit-sharing and co-partnership schemes started within the last century, and records that over 50 per cent. of them had been abandoned according to the Government report on the subject in 1920. Lord Emmott's considered opinion, to which in view of his experience great weight must be attributed, is that "the best remedy for industrial unrest and the best method or removing certain admitted grievances in private enterprise is to work towards a condition of affairs in which under a fairer division of profits, the worker would become a capitalist and the bourgeois capitalist become *pro tanto* less necessary." Experience, he continues, shows that the average worker will not become a capitalist even on a small scale unless and until he is educated, partly by inducements and partly by compulsion to become one. When, however, he is so educated and has acquired an appreciation of thrift, he can be trusted with a share of control which he would not exercise wisely while lacking in personal experience of what productive capital means and how it functions.

Lord Emmott's opinions as quoted, we believe to be absolutely sound, but they do not seem to meet the immediate necessities of the case. If one tries to persuade the average workman to save some money and invest it, he retorts, often with a certain amount of reason, that his wages do not permit of it. He probably also remarks that if he got a fair share of all the wealth he was creating, then he would be able to save. It does not solve the wage question to give the workers as part of, or in addition to, their wages a number of shares which they are not permitted to dispose of. The British workman wants to get his wages in cash to spend or invest as he likes, and he looks suspiciously on any scheme of compulsory partnership in a firm as interfering with his liberty of action. Bonuses according to the annual profits of the firm also do not meet the case, for they are too remote from individual effort to promote efficiency, and in general are as likely to be squandered as usefully employed. Moreover any kind of profit-sharing system leads to difficulties when losses appear instead of profits. It also introduces discrepancies between the average wages paid in different firms in the same district, which again is a source of industrial irritation.

As matters stand to-day, uniform rates of wages for various classes of workmen exist over fairly wide industrial areas, and the need of the present is that the workmen in each area should be satisfied that their wages will rise and fall in such a way as to ensure that at all times they are getting a fair share of the prosperity of the industry in which they are engaged. Under such conditions, strikes arising out of wage alterations would be practically impossible, as the only point which could be at issue would be the fundamental agreement upon which wage changes were based. We believe that with intelligence and good will on both sides, it would be quite possible to come to some definite understanding as to the way in which industrial profits should be divided between the shareholder and the wage earner. As the sequel to the long and bitter struggle in the coal-mining industry last year, an agreement was arrived at which deserves the closest consideration by all who are interested in industrial matters, on account of the importance of the principle it involves, which we believe is quite new in industry. Cleared of minor details, the principle is this. The wages payable in any district are revised every three months in accordance with the prosperity of the industry during the previous quarter. The gross profits of the industry are divided into the following items: (1) Standard wages, (2) costs of production other than wages, (3) standard profits equal to 17 per cent. of the amount of the standard wages, and (4) surplus. Of this surplus, 17 per cent. goes to the shareholders, and the remaining 83 per cent. is returned to the workmen as wages, over and above the standard wage, during the next quarter.

The percentages mentioned, might or might not be the fairest ones in the engineering industry, but this is a small matter. The great point is that a scheme has been agreed upon in a large and scattered industry, whereby the workers are assured of a perfectly definite share in the prosperity of that industry. They know how much they get out of the profits and how much the capitalists get, and they know that the proportion cannot be varied without their knowledge and consent. The scheme makes for efficiency, as the greater the profits the higher the wages. The wages, moreover, in an area are uniform, and the areas are sufficiently large to ensure that each workman is rewarded according to the average prosperity of a large number of establishments, and does not therefore suffer unduly if his particular firm is unfortunate. There is also nothing in the scheme to prevent direct payment by results in any particular firm, for all that such a scheme would provide for is that the standard rate of the districts shall be settled automatically instead of being the subject of constant negotiations or disputes. The legitimate aspirations of the wage-earner to participate fairly in the profits of his industry, must be gratified if settled peace is ever to be brought about, and the only effective answer to wild talk of nationalisation and other disastrous adventures is to meet it with a constructive policy which will satisfy the manual worker that his reaping shall be proportionate to his sowing.

THE WORK OF THE WILLIAM FROUDE TANK.

The present position and future prospects of the shipping industry are such that it is hardly possible to lay too much stress upon the importance of employing all available means to increase the efficiency of our mercantile marine. Sooner or later a considerable quantity of the obsolescent tonnage now in existence, if not in service, must be replaced by new construction, and if this new tonnage is to secure an adequate share of the world's carrying trade in face of the severe competition which seems inevitable, the question of its efficiency must seriously engage the attention of shipowners and shipbuilders alike. In the case of cargo steamers, which comprise the bulk of our merchant vessels, it is particularly important for operating costs to be reduced to the lowest possible limit in order to enable low freights to be quoted without loss to the owners.

The chief item in the operating costs of a cargo steamer is the fuel consumed for propulsion, so that the efforts made in recent years to improve the efficiency of marine propelling machinery are fully justified. Something can also be done to reduce fuel consumption by improvements in the form of the hull of a vessel of any given carrying capacity, such improvements being rendered possible by investigations of the resistance carried out on models in an experimental tank before the vessel is constructed. In some cases, a reduction of 10 per cent. in the power required for propulsion has resulted from such investigations made in the William Froude Tank at the National Physical Laboratory.

That shipbuilders and others have made good use of the facilities available at that Institution may be gathered from the fact that the report of the Advisory Committee of the tank for the year ended December 31 last, mentions that, in previous years, the number of tests made for private firms has left the staff but little time for pure research work. It is one of the very few consoling features of the serious decline in shipbuilding work, which set in during 1921, that the consequent diminution in the number of tests required by private firms has since enabled a much greater volume of research work to be carried out in the tank. The importance of this lies in the fact that investigations for private firms usually have reference to one vessel, or class of vessel only, whereas the results of pure research work are of more general application and are likely to result in improved efficiency of the mercantile marine as a whole. It is true that, in some cases, private firms have allowed the results of special investigations carried out at their expense to be published for the benefit of the whole community, but altruism of this order cannot be expected to be general and, moreover, the investigations, more often than not, are not of public interest.

To provide more time for research work, the hours during which the tank is employed have been increased so that, for five days a week, work is proceeding from 7.45 a.m. to 9 p.m., and this, together with a small increase in the staff, has enabled about 50 per cent. more tests to be carried out in a given time. The hours of work, however, have been arranged so that no overtime is worked, and no particular hardship is involved in the case of any individual member of the staff. This is, of course, a very important consideration, since the quality of the work would undoubtedly suffer if the staff were continuously overworked.

As a result of the decline in shipbuilding, above referred to, the number of tests made for private firms during the last half of the year was less than at any time since 1913. The actual number of models tested for resistance in the whole year ended November 30, 1921, was 38, and, in one case, a reduction of 7·5 per cent. was obtained in the power required to propel the ship at its service speed without alteration to the main dimensions or the displacement. An interesting matter has arisen from the analysis of some trial data for single-screw ships of moderate speeds. Such trials are frequently carried out in ballast conditions, but the tank staff are endeavouring to arrange a specification which will enable the ship's capabilities in the fully-loaded condition to be deduced from trials in ballast. For this purpose it would be necessary to make resistance and screw experiments on a model under both loaded and trial conditions, and by comparing the data obtained from the model under the two conditions with the ship data obtained in the light condition the results for the ship in the loaded condition can be estimated with good accuracy.

Mr. J. L. Kent's research on the influence of waves on the resistance to propulsion and the pitching of ships was completed during the year, and was dealt with by him in a paper read at the Spring Meeting of the Institution of Naval Architects this year. This paper was reprinted on pages 668 and 700 of our last volume, to which we must refer our readers for further particulars. The research on the manœuvring of ships, at the time the report was drafted, had been confined to tests of unbalanced rudders in open-water conditions, either behind a fin or a ship model with a prismatic coefficient of 0·78 and having a single screw propeller; the type of ship represented would be suitable for economical working at from 10 knots to 12 knots and would have a length of 400 ft. The objects of the experiments have been to determine the effect of the form of rudder on the torque on the rudder stock and on the steering power of the ship, the effect of the propeller race on these quantities, the effect of the adjacent ship form on the rudder, and the laws governing the application of model results to full-size ships. Particulars of the work, as far as it had proceeded at that time, were given in a paper by Mr. G. S. Baker and Mr. G. H. Bottomley, read before the Institution of Engineers and Shipbuilders in Scotland in March last. Some comments on this paper will be found on page 364 of our last volume.

Experimental work with screw propellers is proceeding, and progress is also being made in the research on the interaction between passing ships. Experiments on the last-mentioned subject, it will be remembered, were made some years ago as a result of a collision between H.M.S. Hawke and the S.S. Olympic, due to this particular effect. In the present investigation, systematic measurements will be made to determine the effect of depth of water, width of free-water passage between the ships, and other matters affecting the problem. Aeronautical work for private firms during the year was limited to the investigations of various modifications of one amphibious machine, but tests were also made for the Air Ministry on a new form of hull for a flying boat designed to remain upright without the use of floats on the wing tips; the experiments resulted in a considerable improvement in stability. A combined investigation to be conducted by the Aerodynamics Department and the Tank Department in connection with the comparison of model experiments in air and water is also referred to in the Report.

In the above brief outline of the work of the year it has been impossible to mention the whole of the investigations completed or in progress. We have, however, endeavoured to indicate the general character and scope of the work, mainly to show that it has a by no means remote connection with the progress of shipping and shipbuilding. These industries, which are of vital importance to the prosperity of the country, are at present passing through a period of severe depression, and it is in times such as these that particular regard must be had to possible economies resulting from the efforts of scientific investigators and others.

THE DOMESTIC SMOKE NUISANCE.

It has been estimated that some 50 per cent. of the impurities in the atmosphere of our large towns is due to smoke from domestic fireplaces. This smoke is of a more objectionable quality than that produced by the majority of industrial plants, as it may contain from 30 per cent. to 40 per cent. of oily hydrocarbons which assist the formation of black fog and render it more tenacious when formed. The campaign which has now been carried on for many years with the idea of reducing the smoke nuisance has had for its objects the reduction both of industrial and domestic smoke, and although the former is frequently defended as an outcome of trade necessities, it has been fairly successfully attacked in many towns. It offers an easier target than domestic smoke. One can fine the owner of a large works for producing smoke of a blackness exceeding some arbitrary limit, but it is difficult to deal with the individual dwellers in the streets around his factory, the total products of whose kitchen and parlour chimneys may well add more to the insalubrity of the neighbourhood than the more conspicuous smoke of the factory.

The question of smoke abatement was referred to a Departmental Committee by the President of the Local Government Board in 1914. The work of the committee was stopped by the war, but after reconstitution by the Minister of Health at the beginning of 1920, the committee reported in December, 1921. In June, 1920, it issued an interim report having particular reference to the domestic smoke question in its relation to Government housing schemes which at that time were in full spate. The report recommended that the "Central Housing Authority should decline to sanction any housing scheme submitted by a local authority, or public utility society, unless specific provision is made in the plans for the adoption of smokeless methods." Little or no attention appears to have been paid to this recommendation by any body concerned, and a natural disappointment appears to be expressed in a paper entitled "The Economy of Smoke Abatement," which was read by Ex-Bailie William B. Smith, of Glasgow, before the Royal Society of Arts on the 22nd inst. Mr. Smith was a member of the Departmental Committee to which we have referred, and is obviously keenly interested in this question. The failure to take advantage of a smoke reduction possibility on almost a national scale cannot but be looked at as a serious set-back for the movement.

Most of the advances in this world are made by enthusiasts, and enthusiasts are apt to overlook, or minimise, the objections to their ideals. This is the way in which they wear down opposition and enable progress to be made. Those who have taken up the question of smoke abatement from domestic chimneys are apt to act in this way. The way is a good one and spreads their ideals, but always leaves them open to the suggestion that they do not look at the problem as a whole. The factor in the domestic smoke problem which the enthusiasts are apt to overlook is that of cost. The proposals of the report to which we have referred were briefly to the effect that houses should be fitted with a coke boiler for the hot water supply and for warming the living room, a gas cooker in the scullery and gas fires in the bedrooms. Alternatively, electrical arrangements are recommended in place of gas, the coke boiler being retained. Mr .Smith states that the bedroom gas fires would be provided with narrow flues made in special bricks forming part of the walls, and that this construction would save money as compared with the ordinary coal-fire construction involving deeper fireplaces, wider flues and chimneys. This may be so, but even here it is not clear if it is claimed that the overall cost, including the gas fire as against the small grate fixed in bedrooms of the type under discussion, would be less.

It is obvious that this proposed arrangement is suitable only for houses with a single living room, which are inhabited by a class having little money to spare for luxuries. They are certainly not in the habit of having fires in their bedrooms, and clearly a cheaper arrangement than that proposed can be obtained by limiting the installation to the coke boiler and the gas fire. We are fully aware of the convenience of a gas fire in a bedroom, but in considering smoke abatement, or any other subject, it is always useful to keep the practical affairs of life in mind. The people for whom the houses under discussion are supposed to be built would never dream of having a fire in any bedroom except in case of serious illness, and the fitting of an ordinary grate in one bedroom would meet all their requirements and would add little—unfortunately little—to the smoke of any town. As a result of the research on the coal fire conducted by Dr. Margaret Fishenden for the Manchester Corporation Air Pollution Advisory Board, and of which a report was published by the Fuel Research Board in 1920, it was shown that with coal at 45*s.* a ton and gas at 4*s.* 6*d.* per 1,000 cub. ft., a gas fire for the same effect in the room costs three times as much as a coal fire. The people who should live in the houses we are discussing cannot afford to pay three times as much as they need for anything.

The same sort of argument applies to the fitting of a fire on which no cooking can be done, and the installation of a gas cooker alongside it. The kitchen range has had many hard words, but it does give some hot water, warms the house and carries out the cooking, and as long as people inhabiting houses with one living room can do all this work on one solid fuel fire, which is the cheapest kind of fire they can get, they will prefer to do it. It is not only single-living-room householders, however, who are interested in the running costs of their heating and cooking arrangements, and, although it would assist in smoke abatement, the average superior working man and lower middle class man cannot afford to heat his living rooms entirely by gas. The gas fire and the gas cooker have made remarkable progress in the last ten years or so, but it has not been out of any regard for fog on the part of the users. The matter has been forced by domestic labour difficulties. Much has been done, but far more remains to be done if a serious contribution to smoke abatement is to be made. The matter stops where it is now because the user cannot afford to go any further. An excellent and wonderfully convenient gas-heated circulator will be fixed by any gas authority either in conjunction with, or in place of, the ordinary kitchen boiler, and will give an admirable supply of hot water to any ordinary house. We do not know how many of these circulators are installed in London, but that the number might be greatly increased with benefit both to smoke abatement and the domestic labour question there is no question. The average householder is, however, not prepared to meet the cost of employing this convenience.

The most useful work anyone who is interested in smoke abatement can do is to agitate for and, if possible, help towards a reduction in the price of gas. If the cost of gas could be reduced by half it would in a few years do more towards solving the domestic smoke problem than all the reports ever written. It would do this as a by-product of its effect on the domestic labour problem. The gas companies now sell gas by heating value. One of the reasons for this method having been introduced is to give them more freedom in producing a gas suitable for modern requirements. So far the transference from cubic feet to therms seems to have been mainly a matter of arithmetic. If the transference can be made also to cover a cheaper fuel, another step will have been made towards the elimination of black fog. The smoke abatement people might also do something by making it possible for the ordinary domestic user to purchase the semi-coked fuels about which so much has been written, but which the householder has never seen. It is essential, however, that these products should be cheaper than coal. It is useless to offer a material which looks like coke and is certainly more difficult to ignite than coal, unless the price is attractive.

SAFETY IN MINING.

Often in the excitement of public discussion charges are raised which will bear no calm scrutiny. Frequently, for instance, we have had the representatives of labour contending that nothing has been done to diminish the risk of accidents in coal mines. A few years ago it was quite a common thing to hear the opinion voiced by a certain section of the people of this country, that no steps had been taken by the Indian Government in the direction of famine relief. Whenever a larger misfortune than usual occurs unscrupulous use is made of the fact in the endeavour to discredit existing authorities, and play is made upon the emotional nature of the ignorant. Too often the first sensational charge gains currency, while rebutting evidence is accorded no adequate prominence.

The subject of accidents in coal mines formed the main topic of the address delivered on Thursday, the 16th inst., by Professor Sir John Cadman, K.C.M.G., before the Institution of Mining Engineers. This Institution, Sir John reminded his hearers, was formed by a federation of seven separate bodies, and it was an interesting fact that six of these seven had at the time of their origin placed the prevention of accidents in the very forefront of their programme. This was specifically mentioned, and was distinct from the general advancement of the science of mining, ventilation and so on. The Institution itself had kept the matter prominently to the fore, and Sir John claimed that practically all the researches that had been conducted in regard to accidents in mines had originated directly through it, or indirectly through its members. Many of the most useful experiments had been conducted at the expense of bodies now forming part of the federation, while nearly all members of the Special Committee which dealt with coal dust and stone dust experiments were past presidents of the component societies.

This is a good record, and though Sir John takes care not to advance claims of too exclusive a nature, the resulting effect on the mining industry must have been material since the movement has been clearly supported by the bulk of the members, who, of course, as responsible officials and engineers, may generally be taken to be in positions in which their weight on the side of reform or improved methods, would prove effective. The great diminution in coal-mining accidents is shown by the fact that though the output of coal had increased from 50,000,000 tons in 1852 to 250,000,000 tons in 1914, the loss of life which was about 900 in the earlier year had only risen by 300 in spite of the fivefold increase of output. The most impressive accidents which arouse the sympathy of the country are actually few in number, while the isolated fatalities due to falls of roof and so on, total in reality a higher figure, but seldom, if ever, reach the ear of the public.

The note which was sounded by Sir John Cadman

was also struck by His Royal Highness the Prince of Wales at the dinner which he attended on Thursday, the 16th, of the Institution of Mining Engineers, and the Institution of Mining and Metallurgy. His Royal Highness drew a parallel between mining and seafaring. Both were dangerous callings, which were recruited from the section of our manhood which was not diverted from its path by obstacles or danger. As we had built up the greatest reputation in the world as a maritime nation by the skill of our seamen and the attention we paid towards safety at sea, so it behoved us to do all that was possible towards ensuring safety underground. The progress made in this matter was largely the result of the efforts of the Institution.

Sir John Cadman indicated two directions in which he hoped the Institution would move. One was in taking up and completing the work done up till the present on coal dust by disseminating the latest scientific data on the subject and of effective methods of applying preventives. The second was the official representation of the Institution at public inquiries into mine explosions. We take it that the latter is not proposed for the purpose of watching over the interests of members who may be implicated, but to enable the Institution to obtain through its own experts first-hand knowledge of all the facts of a case, and so, by laying before its members a report in some form, to assist in preventing if possible a recurrence. Sir John can, we think, rightly claim that the long record of disinterested service to the credit of the Institution entitles it to assist in this way, while its experts may quite possibly contribute to the value of the investigations.

NOTES.

Tube Developments and Extensions.

Amongst the engineering schemes to be submitted to Parliament this session are certain very important "tube" developments proposed by the London Electric Railway, the City and South London Railway, and the Wimbledon and Sutton Railway. It is common knowledge that a start has at last been made on the widening of the City and South London line. This work would have been commenced in 1914, but was brought to a stop by the war. It is now being carried out at a cost of 3½ million pounds. The widened line will be capable of carrying a much heavier traffic, and to provide this the companies concerned have decided to extend the system from its present terminus at Clapham to Morden via Balham, Tooting and Merton. At Morden a junction will be made with the authorised lines of the Wimbledon and Sutton Company. As a supplement to this scheme the Hampstead tube is to be extended to a junction with the City and South London metals at Kennington. Other work contemplated includes the enlargement of the existing stations at Piccadilly Circus and Leicester Square. At Waterloo escalators are to be installed, giving access to the platforms of the London and South Western Railway. The total cost of the new works is estimated at between 6,000,000*l.* and 7,000,000*l.*, which will bring up to 17,000,000*l.* the total capital expenditure on the underground system since the war.

Water and Tidal Power.

In delivering his presidential address before the Newcastle-upon-Tyne Association of the Institution of Civil Engineers on the 20th inst., Mr. R. F. Hindmarsh, chief engineer of the Tyne Improvement Commission, selected for his main topic water and tidal power. In dealing with this subject, Mr. Hindmarsh referred to the early use of water wheels in Egypt, which, as regards design, persisted practically without improvement until the eighteenth century. Tidal wheels had been in use in America, Spain and France, but their small size and the fact that they worked intermittently made them unsuited to industrial use. We owed the modern water turbine to France, and the more recent developments and improvements in turbines and in electrical machines had made possible great advances in the development of water power resources of recent years. The total potential water power in the world was estimated at 200 million horse-power, of which so far only about 25 millions had been utilised. Even to develop this amount of power, however, would take the whole output of the coal mines of this country. Here at present only about 200,000 horse-power are developed by means of water power, but there were still resources which might be developed to an amount equalling that produced at Niagara Falls, or by the 410 public steam plants now supplying electricity to railways and tramways. If barrages were to be erected across navigable estuaries, it would be necessary to select places where navigation and other important interests would not be interfered with. Engineers should give the question of utilising water and tidal power their close attention, as coal was too valuable to be burned under boilers if other sources of power were available.

HYDRO-ELECTRIC POWER IN INDIA.

There was a touch of pessimism running through the paper read by Mr. J. W. Meares before the Indian Section of the Royal Society of Arts on Friday last, which we fear will awake sympathy in the hearts of a good number of people of this country who have devoted the best years of their lives to the service of the Indian Empire. It is said to be the special privilege of the Englishman who has lived East of Suez to grumble, and it is the fact that the constant striving against odds in an Eastern atmosphere tends to develop this propensity. It is, however, to the credit of the nature of our race that though facing such conditions for a good part of a lifetime Englishmen as a rule do not become embittered nor do they lose heart in the struggle.

Circumstances unfortunately impelled Mr. Meares to describe his paper as a funeral oration. His subject, "The Development of Water Power in India," naturally led him to speak a good deal on the hydro-electric survey of that country, which, inaugurated in 1918, is now practically in suspense. Whatever else of advantage the Montagu-Chelmsford Reform Scheme may be going to confer on India it certainly has not led to the encouragement of investigations of the type of the hydro-electric survey. Such a survey is generally recognised now as being most suitable for organisation by the central government of a country. During the war and since much has been heard of co-ordination and collation. India has not profited, however, and the hydro-electric survey has come to grief because the question has been transferred from Imperial, into provincial hands. Had it been allowed to remain an Imperial subject the survey might have been carried far enough to produce results of considerable value. As it is the work cannot conclude satisfactorily though, as Mr. Meares hopes, the information collected may still prove of some value.

There is no getting away from the fact that in the Orient oriental ideas persist in a dogged manner which must be decidedly painful to all those enthusiasts who, by a few acts of the legislature, think they can open a completely new vista to a people. In India it was formerly the solicitude of the British to govern the country and to make its development gradually possible. The more recent idea has been that the country can best develop itself if sufficient freedom be given to its people. In some directions at any rate the result of the change has been that political freedom has been accepted as a means of returning to the industrial inaction to which the mass of the population has ever been accustomed, and a state of somnolence bids fair to succeed to one in which the country was being slowly and very, very gently led to look at things from what Western people think a more progressive point of view. Hitherto British capital and enterprise has been responsible for almost the whole of the industrial development of the country. Latterly, native capital has been forthcoming to some extent, but the time has not yet arrived when the people of India can be regarded as ready to transform themselves, by their own effort, into an industrial population. The obscurity of the political situation is also at the present time inimical to the free contribution of British capital formerly experienced, so that the immediate future is more than likely to witness a slowing down of British enterprise, without any corresponding growth of native effort.

The information available for future use points, Mr. Meares considers, to the possibility of about 17,000,000 of electrical horse-power being capable of development as the maximum, on the basis of "maximum development" adopted in Canada,* while about 10,000,000 e.h.p. could be developed as "ordinary minimum power," and 7,000,000 as absolute minimum continuous power. The schemes would, however, vary greatly in cost, and this question would have to be very carefully gone into before many of the projects were definitely embarked upon, since the work to date has consisted mainly of reconnaissance. We do not propose to go into detail as regards the distribution of the available resources of the country. Anyone acquainted with India will realise that this is very unequal. We may remark, however, that Mr. Meares directs attention to figures drawn from his last report to the Government of India, to the effect that there are known to be five schemes which could be developed to give over 100,000 kw., while four others could be developed to the extent of between 50,000 kw. and 100,000 kw., and 14 more between 20,000 kw. and 50,000 kw. There is thus the possibility of a good many installations of some size, and we trust our British firms will rise to these opportunities when they come, or better still, see if they cannot be made.

This brings us to a point in Mr. Meares' paper of which our manufacturers should, in their own interests, take particular note. Mr. Meares complains that India has not troubled itself much about his reports, but that "in America, *where the plant comes from*," infinitely more interest has been taken in them. The italics are ours, but the words are Mr. Meares' own, and we draw particular attention to them because such a generalisation in matters of hydro-electric development ought to be an utter impossibility. Further, Mr. Meares suggests that our manufacturers have taken so little interest in this branch of engineering that they are content to deal in small plants limited to a few gallons per minute instead of utilising thousands of cubic feet per second. It is quite true that in this country we have not been able to do much in the way of water power development, but we know that a good many firms here are now in a position to work out large hydro-electric schemes and are doing so at the present moment. Possibly if the war had not occurred, with all its subsequent problems of getting firms back to civil industries, we would be much further ahead than we are. At any rate, we trust our makers will see to it in the future that the idea that hydro-electric plant comes from America proves incorrect, and that in further statements Mr. Meares may be in a position to modify his remarks in this connection.

THE INSTITUTION OF MECHANICAL ENGINEERS.

A meeting of the above Institution was held at the Institution building on the 17th inst., the president, Dr. H. S. Hele-Shaw, being in the chair. The first business was an announcement by the president that the council had decided to offer honorary membership of the Institution to H.R.H. the Duke of York. The president pointed out that this would be done not only out of respect and affection for the Royal Family, but because his Royal Highness has been most zealously concerned with the welfare of the poorer class of lad in engineering works. His Royal Highness had spent his time with these boys and been one with them, taking the welfare question seriously and earnestly to heart. After this and after the disposal of the usual business the president put a proposed alteration of the by-laws to the meeting, and the proposed change was carried unanimously. The change of which notice had been given at a previous meeting eliminated the differential rate of subscription in favour of members residing abroad, which had been in force for some years.

Electric Locomotives.

The meeting then passed to the consideration of the paper bearing the above title, which was read by Sir Vincent L. Raven before the recent Paris

* See page 607 *ante*.

meeting of the Institution. The paper was summarised by Sir Vincent. We need not reproduce his remarks, as the paper was published in full in our issue of June 23 last. In view of our report of the debate which follows it may be a convenience, however, if we say that the paper covers a general review of existing practice in electric locomotive design. Under the heading, Shunting Locomotives details are given of the practice in this direction of the North-Eastern and some American railways. The section dealing with Freight Locomotives is more extended, and the various types of drive which are in use in various countries are dealt with. Sir Vincent sums up in favour of a gear drive, such as is used on the North-Eastern Railway, for freight work in this country, and is not in favour of the various rod drives which are in use particularly on the Continent. The section dealing with Passenger Locomotives again surveys the field, and suggests that the quill drive locomotive which has been built for main line work on the North-Eastern Railway is the most suitable for this country. Sir Vincent suggests that the type might be standardised with us. The North-Eastern locomotive is of the 4-6-4 type, and has three pairs of motors driving through quills. Each motor is of 300 h.p., giving a total of 1,000 h.p. The locomotive works on a 1,500-volt direct-current line and the use of six motors gives considerable flexibility in grouping.

Colonel F. A. Cortez Leigh, of the London and North-Western Railway, opened the discussion. He dealt in the main with various detail points in the paper. Sir Vincent had remarked that the standard freight locomotive should be capable of taking a normal train up the ruling gradient on any ordinary line in Great Britain at about 25 m.p.h. This should enable an average speed of 30 miles an hour to be maintained. This meant that on railways with fairly heavy gradients an engine capable of exerting, say, 2,000 h.p., would be required, and this engine would perhaps only be able to pull some 700 tons. Should it be required to pull heavier weights, two locomotives would seem to be necessary, one pulling and the other pushing, so as not to exceed the 30,000 lb. drawbar pull limited by the strength of the couplings. Of course, such weights were not often met with in this country, but in discussing the paper from the standpoint of standardisation these matters should be borne in mind.

In the section of his paper dealing with freight locomotives, the author stated that for British conditions the most suitable arrangement for an electric freight locomotive was the double bogie design with two four-wheeled bogies articulated together, each bogie containing two motors geared to the two axles. Colonel Leigh felt that in the case of locomotives requiring a continuous rating power of some 2,000 h.p., there might be some difficulty in getting motors of this size within the compass allowed by the bogie and framing. He would suggest having these motors fixed on the body of the engine, adopting an arrangement similar to that carried out on the recent Swiss locomotives.

Sir Vincent had suggested standardising only one class of locomotive for passenger traffic, but Colonel Leigh considered that there should be two at least. On some railways the method of handling passenger traffic varied considerably, and it seemed to him that it would be more economical if a smaller type were standardised, say, for suburban work not capable of being dealt with by the ordinary motor-car system as existing to-day. Referring to the passenger locomotive recently completed by the North-Eastern Railway, it was stated that the "motors shall be able to exert a total average tractive effort of 16,000 lb. at the tread of the driving wheels when starting under normal conditions on level track." He was not clear about this 16,000 lb. The 16,000 lb. did not accomplish what was required by other items of the specification in the paper. He might be mistaken, but apparently the figure worked out according to the requirements should be between 28,000 lb. and 30,000 lb.

Mr. Charles H. Merz, who continued the discussion, said that given a proper system of traction, the electric motor was practically perfect, but the question was, for what purpose did mechanical engineers wish electrical engineers to design the motors? In this country, the question had been largely disposed of by the findings of the committee that had dealt with the subject of system and had reported to the Ministry of Transport. The adoption of electric traction was a commercial question, and should be settled from that point of view. In some countries, however, other considerations frequently arose, such as heavy gradient working, and whether the advantages of regeneration, and the regenerative braking which resulted from it, did not justify special consideration of electric traction. There was also the question of higher speeds on heavy gradient lines, not perhaps possible with the steam locomotive. In this country, physical conditions of that kind were not likely to be met with, and the question was a simple commercial one. From that point of view, it became necessary to arrive at the simplest and cheapest form of locomotive. Sir Vincent had pointed out the conclusions he had come to on the North-Eastern Railway, and, in view of the differences in foreign practice, it might be interesting to call attention to one or two points in connection with freight locomotives, which it was suggested should be standardised.

It might first be noted that that type of locomotive could not be used for single-phase traction with nearly so much convenience, but he hoped that point would not greatly concern us here. A second point which was raised in the paper was the ease with which the bogies could be dropped and any necessary repairs carried out. That, of course, was desirable, but the fact that Sir Vincent had seen his way to recommend that type of locomotive was, in effect, a particular recommendation of the electric motor. It had been argued, as a justification for a different design, in which the motor was placed in the cab, that it was more easily got out, and the fact that the experience of the North-Eastern Railway was that the motor could be put down in the bogie was a proof that the motors had been very satisfactory. He believed the original windings were still running; that the commutators had hardly been touched, and that the brushes had a remarkable life. The motors had not necessitated any dismantling of the locomotive to repair them or take them into the shop; and all that was necessary could be done when the ordinary wheel and bearing repairs took place.

If the locomotive were good enough, as the experience of the North-Eastern Railway had shown it to be, the question of standardisation was important from the point of view of cost. If electric manufacturers were able to put down plant and thoroughly arrange their shop methods for turning out a given equipment and a given size of motor in large quantities, there was no doubt that cost would go down very largely, and it would be possible to equip a line with electric locomotives at a materially lower cost than in the case of steam locomotives. There would, of course, be the electrical equipment also, but in relation to first cost, he felt it could be shown that, having in view the greater availability of the electric locomotive, that the cost of locomotives would be less with electricity than with steam.

Colonel E. Kitson Clark, the next speaker, observed that many things pointed to the adoption of electricity, but the advocates of steam might bring up the question of cost, and the accountant's desk was the final court. In the matter of small repairs, few were required in the case of electrical work; but when it came to the question of the heavy repair period, the electrical engineer was fertile in putting forward new schemes and different principles by which money, it was contended, would be saved. While therefore the electric locomotive might run for a few years with small expense on minor repairs, his experience suggested that when the time arrived for heavy repairs it appeared to be a question of complete replacement.

Colonel Clark then referred to the question of engine frames. It was almost an international question whether the frames should or should not have flexibility; and whether, having decided upon flexibility, plate or bar frames should be employed. He would like to know what the practice was in the cases of separately driven axles and the double connecting rod arrangement illustrated in the paper. Was the principle adopted to make the centre of the engine rigid like a box foundation, allowing the movement to be in the journals and axle boxes; or was a little movement admitted in the frame, so easing the strain on the axle-boxes and possibly keeping the quills or the gears better and more readily in mesh.

Colonel Clark then referred to the question of gearing. When driving, the pinion teeth were at one side of the spur wheel teeth, and in braking they went back to the other side. When starting again the teeth of the pinion travelled back again. He understood that, for electrical purposes, the gears were of such excellent make that there was merely a film of oil in between the teeth, and that reflex action was readily taken up without jar, breakage of tooth or unnecessary noise. The effect, of course, depended upon how far the teeth had been worn. In the tram-cars of a town he knew well, he would almost say that the gears started worn out, the trouble being that it was impracticable to get a pinion and a gear wheel to wear out together, and the wheel proved a good deal more expensive than the pinion, because the wheel was ordinarily thrown away when the pinion was worn out. It would appear desirable that some form of hardening of pinions should be invented, such that the wheel and pinion wore out together.

He was much interested in Sir Vincent's observations on the oscillations of symmetrical engines. It was clear that with two motors vibrating at equal distances about a common centre, the movement of one would accentuate the movement of the other; it was also clear that this effect could not be stopped by springs. Personally he would follow Sir Vincent's example and risk the danger from symmetry; it was obviously easy to change the masses in one place or another. Referring to the trams at Leeds, Colonel Clark pointed out that in going down gradients a great amount of swinging took place. This, he had been told, was not so much due to symmetry, as to wear of tyres, the tyres wearing to a cone form which tended to mount the rails and then slip down again. The matter was cured by truing the tyres and turning a groove of smaller diameter alongside the flange. This method stopped the swinging of the tram-car in an extraordinary way. He did not propose the adoption of the method in the case of electric locomotives, but it might suggest some expedient that could be adopted. The practice seemed an interesting corroboration of Sir Vincent's suggestion that a good deal of the oscillation was attributable to the arrangement of the rails in America.

Major N. E. O'Brien, of the London and North-Western Railway, said it seemed to him too early yet to speak of standardising electric locomotives. A most excellently designed locomotive of one type had been produced and, he believed, was doing its work admirably, but he did not imagine that everybody in Great Britain would accept that as a standard. In the case of the 1,800-h.p. locomotive which had been used on the North-Eastern Railway, the tractive effort seemed rather low when compared with some Continental locomotives. Presumably that fact was due to the intention of using the locomotive on a main line with no very severe or long gradients. On the London and North-Western Railway the severest section on which heavy traffic occurred was between Preston and Carlisle. On that section the average gradient from Carlisle to Shap was, for a distance of 30 miles, in the neighbourhood of 1 in 150, while on the other side, approaching Shap, the gradient was 1 in 75. To deal with heavy passenger trains required on this section a considerably more powerful locomotive than that referred to would, apparently, be required, and the horse-power called for would be of the order of 2,400. Sir Vincent had raised the question of using one large locomotive or two small ones in multiple units. It was improbable that 50 large locomotives would cost more than 75 smaller ones; with a small locomotive, proportioned to the average train but double-headed when a heavier train was drawn the number of locomotive units would probably be increased by 50 per cent., with resulting increase in inspection and repairs. The single large locomotive could deal with any train, and the continuous use of the electric locomotive—an

important factor in the financial success of electric traction—would be greatly facilitated.

Turning to details, Major O'Brien asked what object was served by adopting six motors and also by adopting a twin motor, *i.e.*, two motors of 750 volts, in place of a 1,500-volt motor. On the London and North Western Railway with suburban electric traction at 1,500 volts, where motors and control gear were put to a far severer test than in the case of main line traction, the 1,500-volt motor was perfectly successful. It seemed therefore that the straight 1,500-volt motor with 3-motor equipment was a better arrangement than the six-motor practice. With regard to design of gear, he would like to add some information about the Swiss locomotives. The gear was designed by Brown, Boveri, and was carried outside the wheel and placed on one side only. The arrangement offered the advantage that the axle was not covered up by the sleeve, and the linkage was rather more accessible for oiling purposes, while it could be more easily seen. Moreover, he believed that when it was desirable to drop the axle out, this could be done practically without interfering with anything.

In connection with the matter of oscillation, Major O'Brien stated that he had ridden two or three times on the Swiss gearless locomotive, which was not quite symmetrical, having a bogie at one end and a pony truck at the other, and had found that at 70 miles an hour it ran like a Pullman. This locomotive had 380-h.p. motors, with a total horse-power of 2,400, and pulled a passenger train between Berne and Thun. Whatever might be the trouble in America, the difficulty of riding smoothly at high speeds had been overcome successfully both by the Swiss locomotive and Sir Vincent's design.

It was interesting also to note the reduction indicated by the author in respect to repairs. If an average reduction of about 400*l.* a year in the repair cost of locomotives might be expected, or even 300*l.* a year, the total saving on a division using 200 such locomotives would amount to 80,000*l.* or 60,000*l.* a year, sufficient in the latter case to cover 4 per cent. interest on 1,500,000*l.*. That would leave a margin to pay for the capital cost of electrification, and if the conversion cost could be brought down to the neighbourhood of 20,000*l.* per mile of route, it was probable that a very considerable mileage of mountain divisions in this country would soon be converted to electric traction.

Mr. J. Dalziel, of the Midland Railway, felt that it was early yet to talk of standardising the types of electric locomotive in this country, but he did not think that anyone would severely criticise Sir Vincent Raven's selection of types available. He had no desire to dispute Major O'Brien's contentions, but he could not see how it was possible to get 600-h.p. per axle on the type of locomotive referred to; if this could not be done the three-axle arrangement could not be adhered to, and that arrangement was an essential part of the mechanical design. He felt that Sir Vincent was correct in subordinating the electrical to the mechanical design. On the Midland, early in 1914, the same type of engine as that on the North Eastern Railway had been selected as having the great possibility of future development. As far back as 1908 the company had decided that they could handle heavier trains and maintain greater speed on gradients by using electric locomotives, and could get a greater line capacity.

On the Midland main lines centring round Chinley and radiated to Manchester, Sheffield and Derby, the traffic was fairly dense, with gradients up to 1 in 90, and electrification would be justified in that district if anywhere. On the 1 in 90 Peak Forest gradient, for example, on to-day figures a train of 45 wagons, electrically hauled, could be taken up at 24 miles an hour as against 30 wagons at 8 miles an hour in the case of steam. An hour and four minutes running time could be saved, with a freight train between Derby and Manchester. Therefore for every 100 steam locomotives only 43 electrical locomotives would be needed. It was on that account that the company had determined that the future of British railways would be in the direction of electrification for freight traffic. But even on to-day's prices, he was not satisfied that electrification could be undertaken with commercial advantage. The electrification of the Derby to Manchester line would cost 2,250,000*l.* The traffic could be worked with 115 electric against 251 steam engines, while the operating figures would be 294,000*l.* as against 533,000*l.* With capital charges at 10 per cent. there would still, however, be a debit balance of 3,000*l.* per annum. If manufacturers could bring down equipment cost, especially locomotive cost, the figures would be entirely changed; but, on the other hand, in the reverse direction, a reduction in locomotive coal costs would alter the figures.

He agreed with Sir Vincent that the straight double bogie engine with a single geared motor per axle, was the cheapest to construct and adequate for all requirements. This could be built up to 1,500 h.p., but could not, to-day, be purchased under about 9,000*l.* With greater constructional experience and greater demand, such a locomotive should be purchasable at 5,000*l.*, and the possibilities of electrification would be greater. He could not see why the mechanical parts of such a locomotive should not be produced at less cost, as compared with the mechanical parts of the steam locomotive, apart from the boiler. High centre of gravity was very desirable, and indeed essential, as in steam engines, in order to lengthen the swing of the engine about the longitudinal axis on which it rocked. Low centre of gravity and small wheel diameter were adverse to rail wear. If high centre of gravity, however, were purchased at the cost of using rod and jack shaft designs, it was not worth the price. He did not contend that no rod design could be satisfactory, as some were workable, but he would say that no rod design was necessary so long as Sir Vincent Raven's design of locomotive was available. The use of single-phase was to some extent responsible for the adoption of the designs under discussion, but they were not essential for A.C. locomotives; such designs had succeeded in giving trouble with all types of current.

The wheel arrangement discussed in the paper was very important in relation to high-speed engines. The late Mr. A. W. Gibbs, of the Pennsylvania Railroad, had given results of some important tests on the Pennsylvania Road, showing that certain wheel arrangements were very inferior, for high speeds, while others were satisfactory. Similar information had been published with regard to different types of Continental locomotives by Brown, Boveri and Co., indicating that with one of their locomotives having a bogie at one end and a Bissel truck at the other, the running was better with the bogie leading than with the truck leading. Some very valuable work had been done on the subject of locomotive riding conditions by Mr. Carter, of the British Thomson-Houston Company, whose recent book gave the most complete mathematical analysis of locomotive riding yet available. One of the most important of Mr. Carter's conclusions was that for smooth riding the locomotive should have a leading bogie pivoted centrally or inside the axles, but that the trailing wheel truck should be pivoted externally and in front of the axles. Mr. Carter's proposal to get over the reversal of direction was to fit the locomotive with leading trailing bogies and arrange so that either could be pivoted internally or externally at will. A somewhat similar idea of workable bogie pivoting had, apparently, been simultaneously evolved by Messrs. Ljungström, but with a rather different object, in one of their turbine locomotive designs.

Mr. R. P. C. Sanderson, of the Baldwin Locomotive Works, stated that he possessed detailed reports, relating to every electric railway installation, on the conditions prevailing during the great railway strike in America last summer, and, with one exception everyone of the electrifications ran steadily through the strike, in spite of all shop difficulties over repairs. That showed a degree of reliability never yet reached by steam traction. The one failure was on the Cascade Mountains where the power available was insufficient for starting the trains, and a steam engine had always to be used for the purpose. On one occasion when the engine was not available this led to trouble.

As time did not permit Sir Vincent Raven to reply to the discussion, the President then closed the proceedings with the announcement that an extra general meeting would be held to-night at 6 p.m. to resume the discussion of the paper by Mr. W. Reavell on "Air Compressors," which was read at the Paris meeting. Mr. Reavell had added a note on the "Testing of Air Compressors," which would be read at the meeting.

LITERATURE.

The Nitrogen Industry. By J. R. Partington, D.Sc., and L. H. Parker, M.A., D.Sc., F.I.C. London: Constable and Co. [Price 21*s.* net.]

The term "nitrogen industry" belongs to the present century. We had long had a nitrate and nitric acid industry and an ammonia industry, and various nitrogen compounds had indeed become very important industrial products. But people hardly spoke of a nitrogen industry. They had more or less learnt to acquiesce in the fact that there was little to be done with the nitrogen of our atmosphere which Providence had evidently added as a diluent to the oxygen of the air lest we be burnt up too quickly; people generally understand the why, when they know nothing else. How the sluggishness of atmospheric nitrogen was overcome and how nitrogen was finally fixed, partly by the method with which Cavendish had made us familiar more than a century ago, and partly by modern engineering developments of laboratory methods of the liquefaction of gases, need not be repeated on this occasion.

At present we almost need an incentive to make us study a new book on the "Nitrogen Industry." The names of the authors supply that incentive in the case of the volume before us. Both Dr. Partington and Dr. Parker were on the research staff of the Nitrogen Products Committee of the Ministry of Munitions. They had their share in the work upon which the excellent "Final Report of the Nitrogen Products Committee" was based, and they had exceptional facilities to acquaint themselves with what had been done and what was being done, and to experiment on possible modes of improvement. Most of their investigations were conducted in the years when Mars—the preface speaks of Mars and Ceres—claimed all the nitrogen that could be fixed, whilst Ceres had to be satisfied with what was left. These mutual relations have since undergone a great change; the claims of Ceres predominate, and because they both demand fixed nitrogen, but do not require the same compounds, methods more suitable for the one or the other class of products have assumed different relative importance. With these general aspects we had recently to deal in connection with the discussion on the "Nitrogen Industry," by Section B of the British Association.* Like the speakers at that meeting, Drs. Partington and Parker wisely do not attempt at all to deal with organic nitrogen compounds, explosives as such, dyes, proteins, &c.; they limit themselves to what is understood by the fixation of nitrogen, to nitrogen products and Chile nitrate and to by-product ammonia and ammonium sulphate.

What we look for and find in this volume is technical detail and information, so far as it can be given, about actual plants, complementary in a sense to the classical Report we mentioned. Restrictions are imposed not only by commercial interests. The official Allied Commissioners which were sent to Oppau and to other chemical works did not publish all the information they had acquired. For this and other reasons the qualifying term "probably" occurs repeatedly in the description of the Haber catalytic bombs, steel forgings, 7-in. wall thickness, used in the synthetic ammonia process, and of other apparatus. We do not learn from the book how Claude gets rid of the surplus heat of his high compression, which Claude himself has not explained in his numerous papers; it must be a very difficult problem, especially in the apparatus of "minuscule" dimensions of which Claude proudly spoke in his communication to the Faraday Society.† Nor are we told that the steadiness of the vertical arcs, several metres high, of Schönherr was an almost sensational novelty years ago. But

* Engineering, October 13, page 473, and October 27, pages 536 and 537.

† Engineering, October 20, page 506.

those arcs have lost their interest, and the outstanding problems concern at present the engineer, who has to transform laboratory apparatus into works plant, more than the chemist. In that respect more diagrams would be welcome, if they could be supplied; in some cases a few more literature references might perhaps have been given.

Many of the methods and appliances used in nitrogen works appear complicated; whether they could be simplified, a very intimate study can alone decide. Drs. Partington and Parker make some suggestions as to the direct production of nitrates from converter gas, limestone or lime and soda ash or ammonia, and also as to the oxidation of ammonia. Facilities for a commercial trial plant of the latter process had actually been promised them, when the Department of Explosives Supply took over the Munition Inventions Department; that put an end to their hopes, and the Billingham factory, built for the production of synthetic ammonia, they point out, is not producing yet. Some day the demand for high explosives in our peaceful times may replace the nitrogen industry by an industry of the Rare Gases. So far those "noble" cousins of nitrogen—argon, helium, &c.—have appeared too indifferent to form any compounds at all; but there are certain indications that they enter into temporary combinations in electric discharge tubes, and their inertness might yet be overcome.

The Electrical Handling of Materials; A Manual in Four Volumes, on the Design, Construction and Application of Cranes, Conveyors, Hoists and Elevators. Vol. III *Electric Cranes.* By H. H. Broughton, M.I.Mech.E., M.I.E.E. London: Benn Brothers, Limited. [Price 50*s.* net.]

The economic handling of material in a works is one of the most important considerations which the designer has to deal with. The scope of such work is almost limitless, for so many conditions are imposed upon the designer, due not only to cramped or obstructed space to work in, but also because of the variety of loads, speeds, lifts and the shapes and sizes of materials. The use of electricity in this field has been instrumental in the saving of considerable works costs. The flexibility of the electric drive, the ease of control, and the effective safeguards that are possible, have all contributed to make the use of electric working almost universal. The designer looking for a single work covering this field can be recommended to the study of "The Electrical Handling of Materials," by H. H. Broughton, which is a complete manual in four volumes on the design, construction and application of cranes, conveyors, hoists and elevators. The first two volumes dealt with electrical equipment, and structural steel and mechanical equipment respectively, the latest volume treats of cranes and crane mechanisms.

Crane arrangements are treated broadly in four sections—namely, overhead travelling cranes, gantry cranes and cantilever cranes, jib cranes, and telphers. These sections are further subdivided and the subjects of shipyard cranes and steel works equipments are treated separately. The subdivision in this way has much to recommend it, as it enables emphasis to be made of the peculiarities of the various cases to be dealt with and the methods of solution.

Overhead travelling cranes have the advantage of covering in their traverse along and across the workshop practically the whole area of the floor without interfering in any way with the work which may be in progress and without sacrificing floor space. The multiple motor arrangement permits the use of a simple mechanism and ensures greater reliability and higher speeds than are possible with a single motor driving through the medium of friction clutches. Such cranes can be operated from bridge, trolley, or, although not so desirable, from the floor. When head room is limited the bridge girders must be arranged to allow the trolley to run inside and between them. Where the entire floor has to be served as well as an adjoining building the use of cranes with inverted jibs mounted on a turntable on the trolley or cross girders has met the requirements. Gantry or bridge cranes of considerable size and capacity are used in yards where the provision of elevated runways for overhead travelling cranes would be out of the question on the score of cost and interference with the work in progress.

Examples of actual designs in detail of these cranes are completely described and illustrated with many drawings and photographs in the text, while details of requirements of loads to be dealt with, speeds and energy consumptions are given. Jib cranes and derricks and the telpher system for the rapid and economical handling of goods are described in equal detail and completeness.

The specifications given of illustrative examples of the different types of lifting plant dealt with in the volume will prove very useful to engineers confronted with the problems incidental to the design of any type of industrial works.

This work is perhaps the most successful attempt that has yet been made to deal exhaustively with the many problems connected with the electrical handling of materials.

BOOKS RECEIVED.

Department of Scientific and Industrial Research. Report of the Food Investigation Board for the Year 1921. London, Manchester, Cardiff and Edinburgh; His Majesty's Stationery Office. [Price 2*s.* 1½*d.* post free.]

Researches on the Constitution of Coal. By S. Roy Illingworth, M.Sc., A.R.C.Sc., F.I.C. London: "The Colliery Guardian," Limited. [Price 2*s.* 6*d.*]

The Use of Abrasive Wheels. Safety Pamphlet No. 7. Issued by the Home Office. London, Manchester, Cardiff and Edinburgh: His Majesty's Stationery Office. [Price 1*s.* net.]

Aeronautical Research Committee. Reports and Memoranda. No. 787. *Lateral Control of Bristol Fighter at Low Speeds, Measurement of Rolling and Yawing Moments of Model Wings due to Rolling.* By F. B. Bradfield. London, Manchester, Cardiff and Edinburgh: His Majesty's Stationery Office. [Price 1*s.* 7½*d.* post free.]

The Association of Engineering and Shipbuilding Draughtsmen. Elevating and Conveying Machinery for Handling Loose Bulk Materials. Part II. *Conveyors.* By H. Davies. London: Offices of the Association.

University of London, University College, Calendar, Session 1922–23. London: Taylor and Francis.

Ministry of Munitions and Department of Scientific and Industrial Research. Technical Records of Explosives Supply 1915–18. No. 9. *Heat Transmission.* London, Manchester, Cardiff and Edinburgh: His Majesty's Stationery Office. [Price 5*s.* 3½*d.* post free.]

Zur Bestimmung stromender Flussigkeitsmengen im offenen Gerinne Ein neues Gerinne. Von Dipt-Ing. Oskar Poebing. Berlin: Julius Springer. [Price 2*s.*]

The Blast Furnace and the Manufacture of Pig-Iron. An Elementary Treatise for the Use of the Metallurgical Student and the Furnaceman. By the late Robert Forsythe. Second edition. Completely revised by Carl A. Meissner and J. A. Mohr. New York: U.P.C. Book Company, Inc.

Antiseptic Treatment of Sleepers in India. Technical Paper No. 231. By R. S. Pearson, C.I.E., F.L.S., I.F.S. Calcutta: Superintendent Government Printing. [Price Rs. 1–4.]

United States Bureau of Labour Statistics. Bulletin No. 304. *Proceedings of the Eighth Annual Meeting of the International Association of Industrial Accident Boards and Commissions, Chicago, Ill., September* 19 *to* 23, 1922. Washington: Government Printing Office.

United States Bureau of Mines. Bulletin No. 192. *Carbon Black—Its Manufacture, Properties and Uses.* By R. O. Neal and G. *St.* J. Perrott. [Price 25 cents.] Technical Paper No. 263. *Design and Operation of a Low-Pressure Absorption Plant.* By W. P. Dyrema and A. A. Chenoweth. [Price 10 cents.] No. 285. *Compressed-Air Illness and its Engineering Importance. With a Report of Cases at the East River Tunnels.* By Edward Levy. [Price 10 cents.] No. 302. *Coal-Mine Fatalities in the United States,* 1921. By William W. Adams. [Price 10 cents.] No. 313. *Production of Explosives in the United States During the Calendar Year,* 1921. *With Notes on Mine Accidents due to Explosives.* By William W. Adams. [Price 5 cents.] Washington: Government Printing Office.

Air Ministry, Meteorological Office, British Meteorological and Magnetic Year Book, 1920. Part III. Section 2. *Geophysical Journal,* 1920. London, Manchester, Cardiff and Edinburgh: His Majesty's Stationery Office. [Price 1*l.* 5*s.* 5*d.* post free.]

The Motor Manual. A Practical Handbook dealing with the Working, Principles, Construction and Management of all Types of Motor Cars. Compiled and illustrated by the staff of *The Motor.* Twenty-fourth edition. London: Temple Press, Limited. [Price 2*s.* 6*d.* net.]

"The Gas World."—The 2,000th number of this journal, dated the 18th inst., is a special number containing articles of historical interest on the gas industry by prominent specialists. The articles cover the progress made during the last forty years or so in gas production, distribution and utilisation. The many uses there are for gas, in industrial plants, in commercial houses and in the home are emphasised. The first number of this journal was published on July 26, 1884, and was then entitled *Gas and Water.*

INDUSTRIAL NOTES.

The Ministry of Labour state that employment continued bad during October in nearly all the principal industries, and showed little change, on the whole, as compared with the previous month. There was an improvement in the coal-mining and iron-mining industries, and a further improvement in the pig-iron industry, in the woollen and worsted industries, and in the pottery trades. In the cotton trade, however, a further decline was reported. The percentage unemployed among members of trade unions from which returns are received was 14·1 at the end of October, as compared with 14·6 at the end of September and 15·6 at the end of October, 1921. The percentage unemployed among workpeople insured under the Unemployment Insurance Act was 12 on October 23, the same as on September 25. The total number of workpeople registered at the Employment Exchanges as unemployed on October 30, in Great Britain and Northern Ireland, was approximately 1,385,000, of whom 1,130,000 were men and 176,000 were women, the remainder being boys and girls. At the end of September the number on the live register was 1,368,000, of whom 1,117,000 were men and 168,000 were women. The number of vacancies notified by employers to Exchanges and unfilled on October 30 was 13,700 (of which 3,800 were for men and 8,100 for women), compared with 12,500 on September 25.

In the industries for which statistics are compiled by the Labour Department, the changes in rates of wages reported as having taken effect in October resulted in an aggregate reduction of over 250,000*l.* in the weekly full-time wages of nearly 1,500,000 workpeople, and in an aggregate increase of over 22,000*l.* in the weekly wages of over 400,000 work people. The principal group of workpeople whose rates of wages were reduced were cotton operatives in Lancashire and the neighbouring counties, who sustained a decrease of 10 per cent. on basis piece prices, equivalent to about 5 per cent. on current weekly wages. The wages of dock labourers were reduced by 1*s.* per day or 6*d.* per half-day, and those of tramwaymen by 4*s.* per week in most towns. Railway shopmen employed by most of the principal companies in Great Britain sustained a reduction of 10*s.* per week, and in addition there were changes of various amounts resulting from the standardisation of rates in England and Wales. Other important bodies of workpeople affected by reductions included iron miners, iron puddlers and millmen, blast-furnace workers in Cleveland and Staffordshire, brick and other clay workers, makers of light castings, ship repairers in South Wales, railway wagon builders and repairers, brass workers in Birmingham, workpeople in the textile bleaching, dyeing, &c., industries, road transport workers in London, certain classes of workpeople in the printing trades, cement workers, and men employed by electrical contractors. As a result of orders made under the Trade Boards Acts there were reductions in the minimum rates of wages in the stamped or pressed metal wares trade. The principal increase in wages affected coal miners in Northumberland, and in the Yorkshire and East Midland area, wages being raised, as a result of the ascertainment of the proceeds of the industry for August, by about 6½ per cent. on current rates in the former district and by 2 per cent. on current rates in the latter. There were also small increases in the wages of steel sheet millmen and galvanisers and of blast furnace workers in Nottinghamshire and the West of Scotland. Since the beginning of 1922 the changes in rates of wages reported to the department have resulted in a net reduction of nearly 4,200,000*l.* in the weekly full-time wages of over 7,500,000 workpeople and a net increase of nearly 11,500*l.* in the weekly wages of nearly 75,000 workpeople.

On November 1 the average level of retail prices of all the commodities taken into account in the statistics prepared by the Ministry of Labour (including food, rent, clothing, fuel, light and miscellaneous items) was approximately 80 per cent. above that of July, 1914, as compared with 78 per cent. at September 30.

The number of trade disputes involving stoppages of work, reported to the department as beginning in October, was 32. In addition, 25 disputes which began before October were still in progress at the beginning of the month. The total number of workpeople involved in all disputes in October (including those workpeople thrown out of work at the establishments where disputes occurred, though not themselves parties to the disputes) was nearly 14,000, as compared with 15,000 in the previous month and 23,000 in October, 1921. The estimated aggregate duration of all disputes during October was 186,000 working days, as compared with 142,000 days in September, 1922, and 156,000 days in October, 1921. Since the beginning of 1922 the stoppages of work, owing to trade disputes, reported to the department, have involved over 500,000 workpeople.

The aggregate duration of the stoppages has been nearly 20,000,000 working days.

Mr. C. E. Siddall, managing director of the Sheffield Forge and Rolling Mills, Limited, Millsands Works, Sheffield, has issued a spirited manifesto to his men from which we take the following figures and statements. The result of last year's working was a loss of 53,321*l.* He had taken orders at a loss to find employment for the men when really the works should have been closed down. The output for 1914, pre-war, was 42,619 tons, and wages amounted to 39,680*l.* In 1922, the output was 26,690 tons, and wages 94,330*l.*, so that for 55,000*l.* more paid in wages, the output was 15,929 tons less.

The Iron Trade Review, Cleveland, Ohio, states that Japanese imports from Germany are now declared by the Department of Commerce to be larger than before the war. In the year ended May, 1922, imports from Germany totalled 83,310,000 yen, or 22,150,000 yen more than in 1913. The outlook is that in the calendar year 1922 Japan's imports from Germany will exceed 100,000,000 yen. Chief among the German shipments to Japan are metals and manufactures, scientific instruments, dyestuffs, chemicals and explosives. The yen was valued in October at just over 2*s.* 2*d.*

According to reports from State mine inspectors to the United States Bureau of Mines, there were 153 fatal accidents in the American coal mines in September. Nineteen employees were killed at anthracite mines in Pennsylvania and 134 at bituminous mines throughout the country. In September last year there were 167 fatal accidents, namely 45 at anthracite mines and 122 at bituminous mines. The production of coal was 46,196,000 tons in September, 1922, and 43,329,000 in the corresponding month last year; hence, for each million tons of coal mined the fatality rate for September, 1922, is 3·31, as compared with 3·85 a year ago. The average fatality rate for September during the nine-year period 1913–21 is 3·65 per million tons and the average number of fatalities is 186. Thus the record for September, 1922, shows a reduction both in the actual number of lives lost and the fatality rate per million tons, when compared with September's record a year ago and the general average for the same month since 1913. On September 23 five shaft sinkers were killed by a falling cage while cleaning out a sump. During the nine-month period January to September of the current year, 1,186 men have been killed by accidents at coal mines, as compared with 1,485 killed in the corresponding months last year. The fatality rate per million tons is 3·98 this year as against 4·07 for the first nine months of 1921. Because of the general strike recently closed, the output of coal in 1922 has reached only 298,000,000 tons, while during the nine-month period last year the production was 365,000,000 tons. Fatalities due to falls of roof and coal in 1922 show no change from last year's nine-month record in the number of men killed per million tons of coal mined; the fatality rate from explosives has been reduced 45 per cent. The rate of gas and dust explosion has doubled, but it should be stated that explosions in 1921 resulted in an unusually small loss of life, constituting only 1·7 per cent. of the deaths from all causes combined. Only slight increases are noted in the fatality rates charged to electricity and haulage accidents.

Personal.—Mr. W. J. Belsey, who has been manager of the British Thomson-Houston Company, Limited, Glasgow office, since 1905, has been transferred to the head office at Rugby as manager of the marine department, and Mr. J. Miller has been appointed to succeed him as manager of the Glasgow office.

The Late Mr. Thomas James Dodd.—A widely-known and much-respected friend of all Clyde shipbuilders has passed away in the person of Mr. Thomas James Dodd, who died on Sunday, the 19th inst., at his residence in West Kilbride. For thirty-eight years he served as a surveyor for Lloyd's Register, rising to the responsible position of chief surveyor for the Glasgow district. Mr. Dodd was in his seventy-sixth year, having been born in Portsmouth in 1847. He was trained as a naval architect in the dockyard there. He spent part of his earlier professional life in surveying vessels under construction for the Royal Navy. He was appointed to the staff of Lloyd's Register in 1875, and served as a surveyor in London, Leith, Sunderland, Genoa, Marseilles and Glasgow. He was appointed a member of the Glasgow staff in 1881 and was promoted to the position of principal surveyor in 1889. When he came to Glasgow, Lloyd's Register had only eight surveyors in the district. When he retired, in December, 1913, there were 35. On his retirement he was entertained to dinner by the Scottish staff of the Register, and a large number of shipbuilders and shipowners, and was the recipient of valuable presentations. Mr. Dodd was exceedingly popular in the Clyde district, discharging his responsible duties with the greatest efficiency, and earning the esteem of all associated with shipping, shipbuilding and marine engineering.

UNDERGROUND WATERS IN THE KENT COALFIELD AND THEIR INCIDENCE IN MINING DEVELOPMENT.*

By Edward Otto Forster Brown.

I. The general geological conditions under which the Kent coalfield occurs are described, and attention is drawn to the difficulties encountered in dealing with water both in sinking and in development. The coalfield is overlaid by the Jurassic, Cretaceous and to a lesser extent the Tertiary systems, but the incidence of these rocks varies due to planes of unconformity occurring between them. The important water-bearing horizons to be considered are confined to :—

Formation.	System.
1. The eocene	Tertiary.
2. The chalk	Secondary.
3. The lower greensand	Secondary.
4. The Hastings beds at the base of the Wealden, and	Secondary.
5. The estuarine sands at the base of the great or inferior oolite.	Secondary.

II. *Water-Bearing Characteristics of Formations.*—The main characteristics of the eocene formation are described. At Chislet Colliery they were 195 ft. thick and were sunk through by the drop-shaft method. The general characteristics of the chalk formation, its divisions and zones, are described and shown diagrammatically. The relative vertical range and water-bearing character of chalk passed through by the sinkings for coal and wells for water, put down in Kent, are also shown on the diagram. Some alternative views are put forward to explain the comparatively stronger water-bearing characteristics of the lower middle and lower chalk near the south-west escarpment, as compared with the centre and north-eastern portion of the coalfield. The main fissures in the chalk usually appear to run W.N.W. and E.S.E., and it is indicated how this factor may have some bearing upon the varying water-bearing characteristics of the lower chalk as experienced by the Channel Tunnel trial headings on the English and French coasts respectively. The lower Greensand formation and Hastings beds are described, and a comparative section is submitted showing the character of the beds and the come off water met with at the four colliery sinkings which pass through them. Owing to the plane of unconformity at the base of the Wealden it is pointed out that in the north-eastern part of the coalfield these beds directly overlie the coal measures. The importance of the water-bearing oolite sand beds is emphasised, due to the fact that over a large proportion of the coalfield they make direct contact with the coal measures, and the water therefore tends to percolate into the latter where they are permeable. A comparative section is given showing the character of the beds and their water-bearing features at the four collieries where they have been sunk through or proved. At Shakespeare the great oolite sands were found practically dry, but sands of inferior oolite age underlying them gave off a feeder of 1,500 gallons of water per minute. The static pressure of this water, as indicated by pressure gauges on the tubbing, corresponds with a rest-level of O.D. In sinking the shafts subsequently through the coal measures, a number of new independent feeders of water were met with, which are believed by the author to originate from the same source as the oolite water. At Guildford colliery the sand beds are believed to be of great oolite age and have been proved by borings from the bottom of one of the shafts. According to pressure-gauge readings taken from time to time from 1914 to 1920, the static pressure of this water has remained constant at a pressure corresponding with a rest level of 417 ft. below O.D. At Tilmanstone Colliery the sands, which are of great oolite age, were first tapped by a boring from the bottom of one of the sinking shafts, and the water is stated to have come off at a pressure of 500 lb. per square inch, corresponding with 236 ft. above O.D. Subsequent observations indicate that the rest level corresponding with the pressure of this water is now considerably below O.D. The operations in the 5-ft. seam lying 400 ft. below the sand bed at this colliery, experience in sinking in the coal measures, and the water feeders met with, are discussed at some length. At Snowdown Colliery the sands are also of great oolite age, but were found to be practically free from water in sinking. In No. 2 pit the original feeder of 190 gallons per minute has fallen to 12 gallons per minute, while in sinking No. 3 pit no water was met with at this horizon.

III. *General Considerations affecting Oolite and Coal-Measure Water.*—The variation in incidence as regards pressure and quantity of these waters is discussed, and the geological distribution of the oolite formation in south-east England and northern France is reviewed. Some of the more important springs in this formation in the West of England are mentioned, and attention is drawn to the salinity of the water in several cases. Alternative views are put forward as to the origin of the oolite water met with in Kent, and a description is given of the more salient geological and hydrographical features in the Boulonnais, which the author visited with a view to throwing light on the question. The main faults in the Boulonnais have a bearing of 70 deg. to 75 deg. N.W., while those proved by coal workings in Kent bear 50 deg. to 63 deg. N.W. It is suggested that the bearing of the faults is governed by the bearing of the major Tectonic folds which swing northwards in the neighbourhood of the Straits of Dover.

IV. *Conclusions.*—The following tentative conclusions are arrived at after summing up the available evidence :—

1. The direction of faulting and folding of the earth's crust in and in the neighbourhood of the Kent coalfield has an important direct or indirect bearing upon the incidence of water in all water horizons, except the eocene, at any particular point.

2. The main fissures in the chalk as a general rule appear to conform fairly closely with the direction of the major Tectonic folds.

3. Where pits have been put down through the chalk formation, at points where a considerable thickness of upper chalk exists, water feeders of importance have not been met with below the upper half of the zone *Terebratulina gracilis*. Towards the outcrop of the upper chalk division and the outcrops of the middle and lower chalk, water feeders of importance are met with in pits passing through the two latter divisions, while the presence of important springs at the outcrop and close to the base of the lower chalk has also been noted.

4. The factors governing the incidence of water from the lower greensand and Hastings beds are obscure at points where shafts have been sunk. There appear to be grounds for believing that the distance of such points from the outcrop and the relative thickness of sand at any particular point have a bearing upon the subject. It is also probable that the water in these beds is sometimes divided into independent zones by post-Cretaceous faulting.

5. The water in the sands at the base of the oolites is divided into independent zones by post-Jurassic faulting which conforms in direction with the major Tectonic folds.

6. The water in these different zones varies considerably in quantity and in pressure, and these features may be governed by the geological conditions existing near the south-eastern extremities of the zones.

7. Where the oolite sands overlie the coal measures, great care requires to be exercised in prosecuting underground workings in their vicinity from a relatively dry zone through faults, as on the other side entirely different conditions of quantity and pressure of water in the overlying oolite sands may exist.

8. It is of the highest importance that all possible information should be secured respecting the nature of faults in the coalfield with a view to ascertain which of them are of post-Jurassic age, and therefore likely to form the limits of the various zones.

9. Where, in any particular zone, the oolite sands are present and heavily watered, the water from these beds may percolate to a considerable depth into the permeable coal measure rocks of the upper coal-measure series. The successful working of coal in this series of measures and under the above conditions is consequently liable to be prejudiced by water troubles.

10. Coal worked at a sufficient depth in the lower coal-measure series, even where overlaid by heavily-watered sands, is unlikely to be seriously affected by water, due to the impermeable nature of the bulk of the rocks forming this series.

11. Inferential deductions lead to the conclusion that the Carboniferous limestone, which has been proved immediately to underlie the coal measures in Kent, may be heavily watered, particularly on that side of the coalfield nearest France. In working the deepest seams of the coalfield which are in closest proximity to this formation therefore, care requires to be taken against possible water troubles from below.

The paper concludes with a suggestion that an Anglo-French geological memoir would be of value, comprising the Kent coalfield, the Straits of Dover, and the Boulonnais.

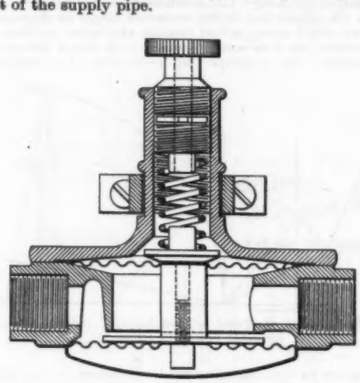
* Abstract of a paper read before the Institution of Civil Engineers, on Tuesday, November 21, 1922.

The Nobel Diesel Engine.—A paper read on the 14th inst. before the Institute of Marine Engineers (Incorporated) by Mr. G. J. Steinheil, dealt with the early general development, and the design of marine engines evolved and constructed by the Russian Nobel Works on the four-stroke cycle. The later work on the two-stroke cycle was dealt with in a second paper read on the 21st inst. The Nobel Works became licencees for Russia for the Diesel engine in 1897, and were thus early in the field. The German engine of that date was not found suitable for Russian conditions, and had to be designed for crude oil, involving important alterations to the fuel pump and atomiser. The first engines were of the crosshead type, but it was not long before the trunk piston type was adopted. With the exception of a small French canal barge fitted with a 20-h.p. Diesel engine, the credit of installing the first marine Diesel engine belongs to Messrs. Nobel. This was built and fitted in 1903 to the tank ship Ssarmat of 800 tons capacity. The engine was non-reversible and was fitted with the Del Proposto drive. A sister ship, the Vandal, was fitted with three Diesel electric sets and electric drive. Their performance was so good that it was decided to convert all the steamers of the Nobel Brothers Petroleum Production Company into motor ships. Of the two vessels the Ssarmat proved the more reliable and economical. In designing for the conversion, the works developed the first reversing marine Diesel engine in the world, in 1907. Following upon the fitting of Nobel Diesel engines to gunboats, monitors and other vessels, the firm undertook to re-engine Russian submarines formerly provided with petrol engines. In working out a suitable design Messrs. Nobel produced an engine of 200 b.h.p., weighing 22 lb. per horse-power, which constituted the lightest Diesel engine made. In his second paper, Mr. Steinheil said the two-stroke cycle was adopted by Nobel in 1901, and in 1902 the firm built their first Diesel engine of this type. In 1905 they had the credit of constructing the first direct reversible Diesel engine in the world, and subsequently developed a number of types of marine engines on the two-stroke system. Since the war, the firm had been started again in Sweden, under the name of the Swenska A/B Nobel Diesel, with works near Stockholm, and were at the present time building large slow-speed marine two-cycle engines.

AUTOMATIC GAS REGULATING VALVE.

The accompanying illustration is a longitudinal section of an interesting and useful form of valve for automatically regulating the supply of gas to gas fires or radiators in order to maintain a uniform temperature in a room. The regulating valve is fitted in the supply pipe between the main stopcock and the fire, the main cock being turned full on, and the supply of gas being cut down as the temperature of the room rises by the action of the regulating valve.

The body and cover of the latter are die castings, and the body is fitted with screwed inlet and outlet connections for the gas. The lower part of the body consists of a capsule, the bottom (or exposed) part of which is formed by a shallow dome of phosphor bronze, while the upper part is closed by a thin corrugated metal diaphragm. To the latter is attached, as shown in the figure, a large bronze disc, which forms the regulating valve proper. Between this and the seating above it a narrow annular space is normally left for the passage of the gas, but as the capsule is filled with a volatile liquid, the increase in the vapour pressure of the latter, due to an increase of temperature in the surrounding atmosphere, will cause the corrugated diaphragm to rise and close the valve. The maximum movement of the diaphragm and valve is only about $\frac{1}{32}$ in., but the diameter of the valve is chosen so that, with the full opening, the area for the passage of the gas is equal to that of the supply pipe.



The upper side of the valve body also contains a flexible diaphragm, and through this the valve stem passes as shown. Bearing on the upper end of the valve stem is a spring enclosed in the neck of the cover, and by varying the pressure of the spring, by means of a knurled-headed screw, the temperature at which the valve closes can be adjusted within certain limits. The position of the screw is indicated externally by a pointer working in a slot cut in the neck of the cover, the sides of the slot being graduated for a temperature range from, say, 55 deg. to 70 deg. Fahr. If the pointer is set to the desired temperature, the valve will be closed when that temperature is exceeded, and opened if the temperature falls below the required degree, although normally the valve remains open just sufficiently to keep the temperature constant. It should be mentioned that the valve is fitted with a by-pass device to prevent the fire from being extinguished when the valve is completely closed. A clip is provided for screwing the regulator to the skirting board or other convenient part. Obviously it must be placed in such a position that it will not be affected by the direct radiant heat from the fire.

The valve is known as the "Loeles," and is made by Mr. George Wilkinson, Beech Mount, Otley-road, Harrogate, who also makes a similar appliance for controlling the temperature of gas-heated ovens for domestic or industrial use. In this, the volatile liquid is contained in a tube, and the regulator is mounted on the side or back of the oven, into which the tube extends horizontally, but the principle employed and the method of temperature adjustment are the same as above described. For domestic ovens, the liquid used gives a temperature range from 315 deg. to 450 deg. Fahr., but for industrial purposes other ranges can be supplied. In a recent test of one of these oven regulators the temperature was maintained steady at 350 deg. Fahr. for 30 minutes, with a consumption of 5·8 cub. ft. of gas, while in an exactly similar oven without the regulating device the temperature rose from 350 deg. to 600 deg. Fahr. in the same time, and the gas consumption was 12·6 cub. ft. The maintenance of a uniform temperature in ovens is, of course, a very important factor in numerous industrial processes; often, in fact, of more importance than considerations of gas economy. The latter, however, is a by no means negligible item at the present time.

THE IMPROVEMENT OF POWER FACTOR.*

By the late Dr. Gisbert Kapp.†

This paper deals with the use of such consuming devices, or the addition to existing consuming devices of such apparatus, as will diminish the phase angle between the vectors representing electromotive force and current. As in the majority of cases the current lags, the improvement in the power factor consists of the pushing forward of the current vector in the direction in which the vectors are rotating; but this is not necessarily always so. With the modern development of long-distance transmission, cases may arise where the current naturally leads, and then we want appliances not to advance it still further, but to retard it.

The primary object of power factor improvement is the better utilisation of the electrical plant and, as far as the supply company is concerned, this includes the generator, step-up and step-down transformers, feeders, mains and switch gear up to the consumers' terminals. Whether the consumer's individual motors have a good power factor does not directly concern the supplier; all he asks is that the consumer shall take from his terminals a current nearly in phase with the voltage. This condition the consumer can always fulfil; either by employing good power factor motors, or by improving his plant by the addition of apparatus which will inject leading k.v.a. into his terminals so as to bring up the general power factor of his installation to a reasonably good figure. That all consumers on a system should voluntarily incur the expense involved cannot be expected. The supplier must therefore make it worth their while, and thus the purely technical question of power factor improvement becomes tied up with the question of suitable tariffs.

This does not, however, exhaust the subject. Even assuming that the supplier were by a suitable tariff able to induce all his consumers to improve the peak-load power factor to unity, he would still have to face the question of his own power factor, not so much on account of the better utilisation of the electrical plant as on account of his being under the obligation of supplying current at a stated voltage. In a small system with only a moderate diversity in the load characteristic between the consumers no difficulty arises, but in an extended system with long feeders the combined effect of reactance, resistance and capacity may be different on every feeder, and this effect will generally tend to make a difference of phase between current and voltage. Therefore correcting devices should be used at the feeder ends. If the load on any particular feeder should be very light a device injecting permanently a given amount of leading k.v.a. would cause the voltage to rise, and that is inadmissible; hence the necessity of an adjustable device such as an idle-running synchronous alternator. Examples will be given later.

Apparatus Used for Power Factor Improvement.—The various appliances may be classified as follows:—

(*a*) Apparatus serving exclusively for injecting leading k.v.a. at the end of a feeder, or at the consumer's terminals, for the purpose of improving the power factor of the system as a whole without affecting that of individual consuming devices. To this class belong the static condenser and the idle-running synchronous machine also known under the names dynamic condenser, rotary condenser, or synchronous condenser.

(*b*) The over-excited synchronous motor serving for the double purpose of producing motive power and injecting leading k.v.a. into the system, and thus making up to a certain extent for lagging k.v.a. taken by other consuming devices on the same system. To this class belongs also the alternating current to direct current converter used in traction stations, the synchronous motor generator and the synchronous induction motor.

(*c*) The rotary or oscillating phase advancer acting on the slip-ring current of a motor so as to improve the power factor of this individual motor and, incidentally, also increase its overload capacity.

(*d*) The alternating-current commutator machine or rotary phase advancer applied to the slip rings of the motor and serving the double purpose of improving the power factor and acting as a slip regulator.

These various classes are considered further on, but before entering into questions of detail it is expedient to consider:

The Economical Limit to Power Factor Improvement in Relation to Capital Outlay.—The introduction of any kind of power factor improver to existing motors or other consuming devices necessarily involves some capital expenditure, but at the same time it reduces the capital cost of the electrical part of the generating and transmitting plant. Where, as in a private works, the supplier is also the consumer, the relation between extra expense on the consuming plant and saving of expense on the supply plant is direct and obvious. In the case of a supply company and its many consumers this relation may at first sight not be so obvious, nor so simple, because many non-technical considerations enter into the commercial business of buying and selling. Nevertheless the relation exists. If the customer cannot participate to a reasonable extent in the benefit he confers by installing plant of good power factor, he will naturally refrain from doing so. On the other hand, if the customer demanded so large a reduction in tariff as to swallow up all the benefit, the company would naturally refuse to give that reduction and there would again be no phase-advancing, to the detriment of both parties. Thus the problem of the economic limit of power factor improvement is largely dependent on the cost of suitable apparatus, on the one hand, and the saving effected in the cost of saleable or available kilowatts on the other.

When treating the question on broad lines and mathematically, we are therefore justified in taking the case of a private works, and we are indeed compelled to do so, because no mathematical formula can take account of the many side issues that may be raised between supplier and consumer which, even if not preponderant, must obscure the mathematical reasoning.

Let us then assume that a private works with a prospective peak load of 1,000 kw. is to be established. The load may be provided for without the assistance of any provision for power factor improvement, and its cost will then be a maximum because the electrical part of the generating and transmitting plant is proportional to the k.v.a. (not the kilowatt) demand; or power-factor-improving apparatus may be used, in which case the generating and transmitting plant will be cheaper, but the consuming plant will cost more. The question is: How far should power-factor-improving be carried so that the total cost becomes a minimum? The influence of power factor on the capital outlay for the prime mover is only indirect and is generally small, though it may be considerable with regard to working expenses. As we are now dealing only with capital outlay we disregard this part of the problem.

Let C = cost of generating and transmission plant per kilowatt from the alternator to the points of supply at unity power factor.

ϕ_0 be the angle of phase difference between the current and voltage vectors when no phase-improving apparatus is used.*

$\frac{C}{\cos \phi_0}$ = corresponding cost per kilowatt at a power factor of $\cos \phi_0$.

c = cost of phase-improving plant per wattless k.v.a. injected into the supply terminals.

$a = \frac{c}{C}$

$\cos \phi$ = most economical power factor to which the whole system can be brought.

Both $\cos \phi_0$ and $\cos \phi$ are for peak load, not average power factors.

The total cost (excluding consuming devices) of the electrical plant is, per kilowatt:—

$\frac{C}{\cos \phi_0}$ . . . without power factor improvement.

$\frac{C}{\cos \phi} + a\,C\,(\tan \phi_0 - \tan \phi)$ with power factor improvement.

This becomes a minimum for

$$\sin \phi = a$$

and the total cost for a peak load of P kw. is

$$P\,C\,[\sqrt{(1 - a^2)} + a \tan \phi_0]$$

instead of $P\,C/\cos \phi_0$ without power factor improvement.

The peak-load power factor to which the installation as a whole should be improved is

$$\cos \phi = \sqrt{(1 - a^2)} \quad . \quad . \quad (1)$$

and the saving thereby effected is

$$100\,[1 - \cos (\phi_0 - \phi)]$$

per cent of the outlay for generating and transmitting plant without power factor improvement.

It will be seen from equation (1) that the economical limit of power factor improvement does not depend on the power factor of the unimproved plant, but only on the ratio of the cost per kilowatt of the original plant at unity power factor to the cost per wattless k.v.a. injected by the phase advancer.

The relation between a and $\cos \phi$ is simply that of a circle function, thus:

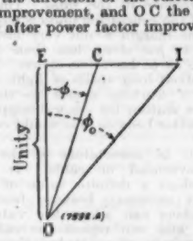
a =	0·1	0·2	0·3	0·4	0·5
$\cos \phi$ =	0·995	0·98	0·955	0·915	0·865

Since a is generally very small (say within the limits 0·1 and 0·3) power factor improvement may economically be carried fairly near to unity power factor, but should not be carried beyond it so as to make ϕ negative. This refers to the installation as a whole, but does not mean that any individual motor may not be worked

* Paper read before the Institution of Electrical Engineers, on November 16, 1922.

† Dr. Kapp died on August 10, 1922.

* The relations between the various quantities considered in this paragraph are apparent from the attached figure. If O E is taken as the direction of voltage vector, O I is the direction of the current vector before power factor improvement, and O C the direction of the current vector after power factor improvement. If O E



is taken as unity and represents to scale the current required for 1 kw. at unity power factor, then O I = $1/\cos\phi_0$; E I = $\tan \phi_0$ = wattless current per kilowatt delivered before improvement; E C = $\tan \phi$ = wattless current per kilowatt after improvement. Then ($\tan \phi_0 - \tan \phi$) represents the wattless current supplied by the power-factor-improving apparatus.—M. W.

with a leading power factor if thereby the overall power factor can be brought up to the economic limit.

From the above mathematical arguments we can deduce a few simple relations as to the cost of power factor improvement if done in the most economical manner as regards capital outlay.

Let K be the cost of the original plant without any improvement; K_1 the cost of the reduced generating and transmitting plant when a phase advancer is added, and A the cost of the phase-advancing plant itself. Let S be the saving in capital outlay through using phase advancers. Then the following relations obtain:

$$S = K - K_1 - A$$

$$K_1 = K \frac{\cos \phi_0}{\cos \phi}$$

$$A = K a \cos \phi_0 (\tan \phi_0 - \tan \phi)$$

$$\frac{A}{K_1} = a \cos \phi (\tan \phi_0 - \tan \phi)$$

$$\frac{S}{K} = 1 - \cos (\phi - \phi_0) \quad . \quad . \quad . \quad (2)$$

The following table shows the saving in capital outlay effected by power factor improvement for a few values of a and cos ϕ_0.

cos ϕ_0	0·6			0·7			0·8		
a ..	0·1	0·2	0·3	0·1	0·2	0·3	0·1	0·2	0·3
S/K in per cent.	32	24	18	22	16	11	14	9	5

To form an opinion as to whether such a saving in initial cost of a private works for 1,000 kw. peak load to be newly established is of importance, we may, by way of example, assume likely values for cos ϕ_0, C and a.

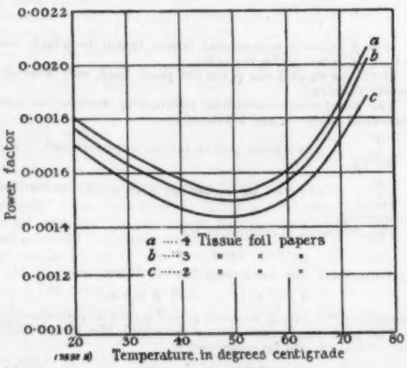


Fig. 1.—Power factor tests on Helsby condenser elements; made at 250 volts and 50 cycles.

A fair value of the peak load power factor is 0·75. This might perhaps seem too low to some, but we must remember that not all the motors will be large or fully loaded even at peak time. There may be a number of small motors and these, or many of them, will generally be underloaded. Very often this is also the case with large motors. As a rule consumers buy their motors rather too large because they want a good margin in torque in the case of short time or sudden overloads. Hence the high full-load power factors which we find in motor lists cannot be expected under average running conditions. The installation may also contain some consuming devices (arc lamps or electric furnaces) with a bad power factor, so that in assuming the overall peak-load power factor to be 0·75 we shall not be far wrong. The estimate of the quantity C is much more uncertain. C includes cost of generators, connections to switchboard, all the switch gear, step-up transformers, protection devices, feeders, step-down transformers, some switch gear at the feeder terminals, and some mains up to the terminals to which the consuming devices are connected. Possibly transformers may be omitted, but heavier feeders will then be required, so that this item cannot make much difference in the total. The influence of size and speed of the generating units is more important; but here also the margin is not very large. It would hardly be safe to put down less than three units of 500 kw. each so as to have one spare. If the process of working involved long spells of light load, bringing the conditions of working nearer to those obtaining in a large power station for general supply, four units might be even better because this would reduce working expenses.

Another factor of uncertainty is the cost of the line, whether overhead or cable. It is obviously impossible to adopt a definite value of C fitting all cases, nor is it necessary because from their own experience members can adopt the value which fits an actual case and can repeat the calculation here given merely by way of example. For the purposes of this example we may take C = 12, which means that the cost of the plant working at unity power factor comes to 12*l.* per kilowatt. The cost of power-factor-improving plant per k.v.a. varies within wide limits; it may be as low as 10*s.* with a phase advancer applied to the slip rings of a very large induction motor, or it may go up to 4*l.* or 5*l.* with static condensers. In order not to overstate the argument for phase-advancing I will take the cost at 3*l.* This makes a = 0·25. We thus find cos $\phi = \sqrt{(1 - 0{\cdot}0625)}$, or

$$\cos \phi = 0{\cdot}968; \ \phi = 14^\circ 30'; \ \phi_0 = 41^\circ 25';$$
$$\phi_0 - \phi = 26^\circ 55'; \ \cos (\phi - \phi_0) = 0{\cdot}89.$$
$$\text{Saving} = 100 - 89 = 11 \text{ per cent.}$$

The installation for the 1,000-kw. peak load would cost $\frac{12}{0{\cdot}75} = 16l.$ per kilowatt, or 16,000*l.* in all for the electrical plant; but by adopting phase-advancing we improve the overall power factor to 0·965 and reduce the total cost to 16,000 minus 11 per cent. of 16,000 = 14,240*l.* Of this sum, about 12,500*l.* is required for generating and transmitting plant, and the remainder, namely 1,740*l.*, for power-factor-improving plant.

The latter has to inject about 600 k.v.a. There are various ways in which this may be done. If there are some large motors among the consuming devices we might provide them with slip-ring phase advancers, or we might use synchronous motors, or self-starting synchronous induction motors, or we may provide squirrel cage motors with static condensers, or we may use a combination of such means. The essential condition is that we must keep within the permissible expense of 3*l.* per injected k.v.a. In other words we must not depart too widely from the rule sin $\phi = a$.

The Effect of Power Factor on the Working Cost of Generation and Transmission.—Whilst the peak-load factor of consumers mainly influences capital outlay and efficiency, a bad power factor at lighter loads increases the cost of generation per unit. There is, moreover, a reduction in the efficiency of generating and transforming plant.

Both have certain losses, such as iron, friction and windage losses, which are dependent on their size but are independent of load, so that the overall efficiency of prime mover, generator and transformer is reduced by bad power factor. It must also be borne in mind that with small load and large k.v.a. output more units must be kept in commission than would suffice with a good power factor; hence working costs are thereby increased. It is therefore to the supply company's interest that the consumer should have a good power factor not only at peak load, but also at lower loads.

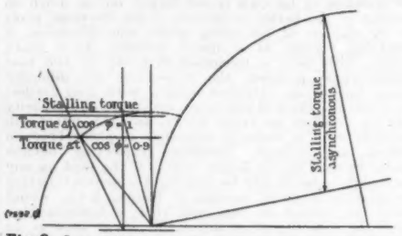


Fig. 2.—Locus diagrams of synchronous induction motor (original power factor 0·89).

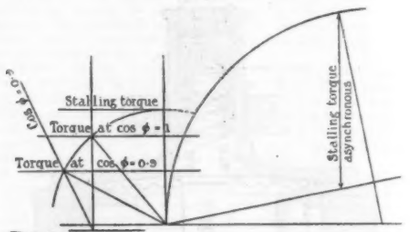


Fig. 3.—Locus diagrams of synchronous induction motor (original power factor 0·73).

The apparatus used for power factor improvement has already been briefly mentioned and will now be considered in somewhat greater detail.

The Rotary Condenser.—Over-excited idle-running machines employed solely for power factor improvement are not generally used by consumers. The only apparatus of this type I have seen was erected in 1896 by advice of the late Mr. Dobrovolsky at the Oerlikon engineering works in connection with the Buelach-Oerlikon transmission (23 km., 15,000 volts at first, later increased to 30,000 volts) and this supplied current to the motors in the works. The firm informed me that a similar machine was at the same time supplied to the works of Messrs. Escher, Wyss and Co., in Zurich.

Recently two rotary condensers, each with an output of 3,000 k.v.a., have been installed by Mr. A. Dickinson* in connection with the Bombay hydro-electric works at the delivery end of the 100,000 volt feeders.

Similar plant, but on a much larger scale, has been installed by the General Electric Company of America in connection with power transmission over very long distances.† Here the main object is phase adjustment, as explained in the beginning of this paper. The largest machine yet built has a capacity of 30,000 k.v.a. when used to advance the phase of the current, and 20,000 k.v.a. when used to retard the phase. It is a 10-pole three-phase 6,600-volt alternator running at a constant speed of 600 r.p.m. The following particulars taken from the test and the illustrations in the publication cited are of interest. The machine has salient poles in the rotor, the stator being the armature. The rotor has a diameter of 2·45 m. and its core length is 2·05 m.

The circumferential speed is no less than 77 m. per second. The exciter is a 150-kw. compound-wound generator giving a maximum current of 600 amperes for over-excitation. Thus only 0·5 per cent. of the maximum k.v.a. output is required for excitation. The output coefficient is 3·5 when the machine acts as a condenser, and 2·35 when it acts as a reactance. It is made self-starting by a damper winding on the rotor supplied by 30 per cent., 37½ per cent. and 45 per cent. taps from the transformer. The damping winding during the start shields the main exciting winding from the effect of the rotating stator field, which would otherwise produce an excessive voltage in the exciting coils. To reduce the mechanical resistance at starting (which is due to the oil being squeezed out when the machine is at rest) oil under pressure is forced beneath the journals to make them float in oil before starting. The bearings are water cooled and the whole machine is cooled by air blast, the volume of air required being 37 m^3 per second. The temperature guarantees are a rise of 50 deg. C. in the stator and 80 deg. C. in the rotor measured by thermometer, and 10 deg. C. more if measured by thermocouple.

Two smaller machines (each 12,000 k.v.a.) were supplied by the same makers in connection with the 22,000-volt transmission of the Andhra Valley Power Company, Bombay. Owing to the higher ambient temperature (45·5 deg. C.) the temperature rise is limited to 45 deg. C. in the stator and 55 deg. C. in the rotor.

I am not aware of any instance where a consumer drawing his supply from a thermic works has put up a rotary condenser on his own premises for power factor improvement; and the reason is not far to seek. The consumer has to pay not only for the energy he consumes in his motors, but also for that which he wastes in his rotary condenser, and that is a considerable amount.

A rotary condenser of some hundreds of k.v.a. cannot be worked with a smaller loss than a generator of equal output. The loss in kw. may be somewhere between 6 per cent. and 7 per cent. of the output in k.v.a. To realise what this means financially we may go back to the case of the private works of 1,000 kw. peak load. At full load of 600 k.v.a. (leading) the machine would require a supply of about 36 kw. to cover its own losses; and although by decreasing the excitation to adapt the condenser to light-load conditions the copper loss in the armature might be decreased, all the other losses would remain the same, so that on the whole the loss would remain very much the same. Moreover, the attempt to economise by constant attention to the changing load conditions would introduce some extra cost of labour. We may thus base the financial argument on the supposition that the number of kilowatts required to cover condenser losses remains constant during the whole time the installation is in use. With a load factor of 26½ per cent. this means 2,300 hours per annum. In a year the rotary condenser would therefore waste 83,000 units. The energy supplied to the motors or other consuming devices amounts to 2,300,000 units. The energy wasted is therefore about 3·6 per cent. of the energy utilised. If the load factor were lower than here assumed the percentage of wasted energy might exceed 4 per cent. It must also be borne in mind that the rotary condenser requires oil and renewal of brushes, perhaps occasionally some repairs, and certainly some slight amount of attendance. For interest, depreciation, maintenance and petty materials it is customary to reckon 15 per cent.

With the machine costing (exciter and switch gear and foundation included) 3*l.* per k.v.a., or in all 1,800*l.*, these charges come to 270*l.*, to which must be added labour, which we shall not over-estimate at 1*l.* a week, thus bringing up the annual cost to 322*l.* At 1*d.* per unit the charge for the supply would be, in round figures:—

	£
Useful energy	9,600
Wasted energy	346

To the latter figure must be added the 322*l.*, so that the rotary condenser costs annually 668*l.*, and to make in this case power factor improvement by rotary condenser a commercial proposition the supply company would have to give a rebate of at least 8 per cent. This is impossible. We may therefore consider the installation of rotary condensers by consumers to be financially unsound.

That rotary condensers are successfully used by supply companies is not due to financial reasons, but to the absolute necessity of giving their distant consumers a constant-voltage supply, for which purpose, in the present state of the art, the rotary machine is the only available apparatus.

The Static Condenser.—A condenser for power factor improvement as made by Messrs. British Insulated and Helsby Cables, Limited, is composed of elements each of about 1 μF capacity suitably grouped to obtain the total capacity required and housed under oil in a tank, much in the same way as a transformer. Also, like a transformer, the static condenser requires no attention and has in this respect a great advantage over any rotary machine. It has the further advantage that its own waste of energy is exceedingly small. The limiting safe voltage on an element of the type mostly used is given by the makers as 600 volts, but for certain purposes

* Journal I.E.E., 1915, vol. liii, page 693.

† *General Electric Review*, 1920, vol. xxiii, page 160.

elements of smaller capacity with a safe voltage limit of 750 volts are also made. The number of elements required depends on the terminal voltage, current and frequency.

Let E be the terminal voltage, ω the circular frequency (for the usual periodicity of 50, $\omega = 314$), P the desired leading k.v.a., c the capacity of one element in microfarads, and e the permissible voltage per element; then a simple calculation shows that the total number of elements is

$$n = \frac{P\,10^9}{\omega\, c\, e^2}$$

The cost varies inversely with the frequency and the square of the voltage per element. If the consumer's terminal voltage is sensibly less than 600 volts it can be brought up to this figure by an auto-transformer. If it is more, it can be brought down to 600 volts or up to a multiple of 600 volts by the same means.

The power factor of a condenser is very small and, consequently, its inherent loss correspondingly low.

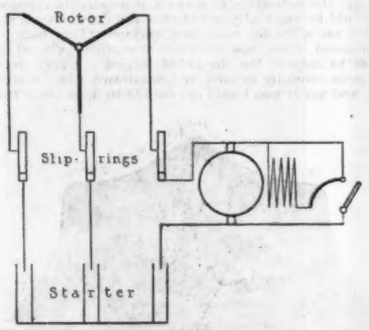


Fig. 4a.—Method of starting a British Westinghouse (case s) synchronous induction motor

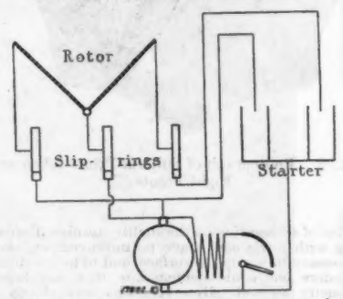


Fig. 4d.—Method of starting a Crompton synchronous induction motor.

The makers claim that it amounts in kilowatts, on an average, to 0·5 per cent. of its output in k.v.a. If a transformer is required there is, of course, an increased loss.

Fig. 1 shows the relation between temperature and power factor for different types of element, oil-immersed, and tested at 250 volts and 50 frequency. In actual work the temperature rise is stated by the makers to be 11 deg. C.

The control apparatus of static condensers consists mainly of oil-immersed switches with auxiliary contacts short-circuiting the condenser when the main switch is opened, and the usual no-volt and overload release and an ammeter.

The following data as to cost have been supplied to me by the makers for a condenser equipment of 100 k.v.a. output, including tank and switch gear, all at 50 frequency:—

Voltage on supply terminals	600	440	440
Transformer ...	Not used	Used	Not used
Condenser voltage ...	600	600	440
Cost	336*l.* 13*s.* 4*d.*	468*l.* 8*s.* 4*d.*	580*l.* 5*s.* 11*d.*

The Synchronous Induction Motor.—The practical application of the idea of using the same machine for the double purpose of providing motive power and at the same time injecting leading k.v.a. into the supply terminals dates back some thirty years, when the Oerlikon Company employed a few such motors in their own shop, the current being derived from the Buelach line already mentioned. It is, of course, convenient that a motor for this purpose should be made self-starting and self-synchronising. If the machine is provided with a wound rotor, like an induction motor, it can be started with a resistance inserted in the rotor circuit, and when it is nearly up to speed a direct current can be passed through the rotor winding so as permanently to magnetise the poles and convert it into a synchronous motor. In order that the motor when so excited shall jump into synchronism the slip must be small and the moment of inertia not too great.* Almost every dynamo maker is ready to supply such motors.

* See paper by E. Rosenberg, Journal I.E.E., 1913, vol. li, page 62.

The various makes differ in detail, but the main principle is the same. In some cases the direct current can be applied during the starting period, so that the process of starting is as simple as with an ordinary induction motor.

The rotor may have salient poles as in an alternator, or it may have non-salient poles. In the former case the starting torque is smaller than with a non-salient pole type; and for this reason, as also for the convenience of using standard frames and stampings, it is generally found that to convert the induction motor to synchronous working is more advantageous than the opposite process, namely, to start with the design of a synchronous machine and convert it into an induction motor.

The working condition of the motor can be represented by a circle diagram much in the same way as that of an ordinary induction motor, only that in the self-starting motor we have two locus curves, the one for the synchronous and the other for the asynchronous condition. With direct-current excitation fixed at a

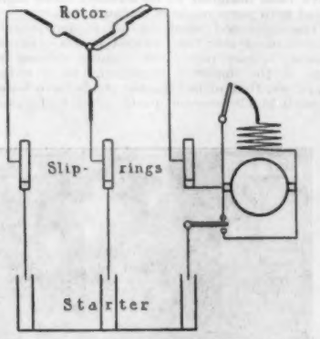


Fig. 4b.—Method of starting an Oerlikon synchronous induction motor.

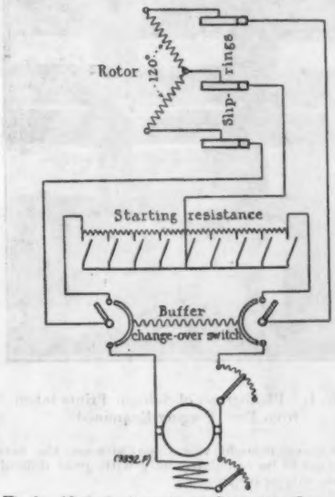


Fig. 4e.—Method of starting a Lancashire Dynamo and Motor Co synchronous induction motor

value just sufficient to give full load at unity power factor (with no saturation in the teeth), the locus for the synchronous condition has a smaller radius. The original power factor of the induction motor to be converted has a considerable influence on the stalling torque in the synchronous condition. This will be seen from Figs. 2 and 3, drawn approximately to scale for the same excitation at all loads, and therefore the same heating in the rotor.

In Fig. 2 the natural power factor of the induction motor is 0·89 and in Fig. 3 it is 0·73. In both diagrams the vectors are inserted for unity and 0·9 leading power factor. Taking as a datum for comparison the torque of the induction motor as 100 in both cases, the diagrams show the following working conditions for constant excitation:—

Original full-load power factor	0·89	0·73
Full-load torque	100	100
Torque at unity power factor	100	86
Torque at 0·9 leading power factor	84	53
Margin to stalling torque in the synchronous condition	Practically none	27
Margin to stalling torque in the asynchronous condition	70	73

The dotted part of the synchronous locus circle indicates an unstable condition. When the motor falls out of step it continues to run as an asynchronous motor. It synchronises again when the load has fallen below stalling load. If the motor is designed for full load at 0·9 power factor it will not fall out of step so easily, but then its k.v.a. capacity must be greater than that of an ordinary induction motor. For this reason, and also because an exciter is required, the cost of a synchronous induction motor must always be greater than that of an ordinary induction motor; and the difference in cost must be the greater the smaller the leading power factor required for full normal load. Examples are given later. Two conditions are necessary for a motor to self-synchronise, namely, a small natural slip and a small mechanical moment of inertia. Modern practice is to put sufficient copper into the rotor to make the slip about 1 per cent. and to keep down the moment of inertia to the lowest possible value; then the motor readily synchronises, even under load or overload.

The switch gear between the rotor slip rings and the starter is shown diagrammatically in Fig. 4*a*, etc., for some of the systems adopted by various makers. Fig. 4*a* illustrates the simple arrangement in which the direct

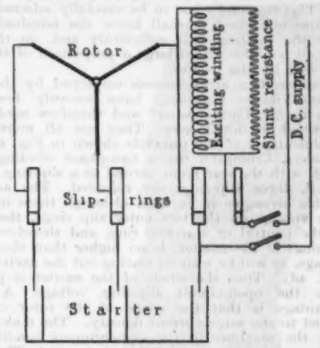


Fig. 4c.—Method of starting a Siemens-Schuckert synchronous induction motor.

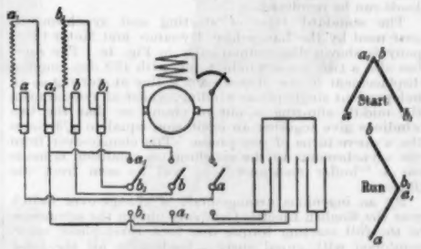


Fig. 4f.—Method of starting an English Electric Co. synchronous induction motor

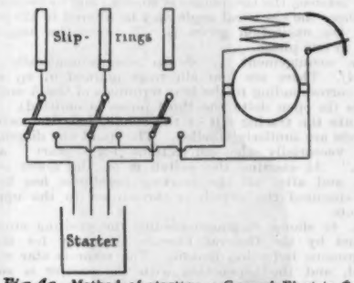


Fig. 4g.—Method of starting a General Electric Co. synchronous induction motor.

current is passed down one phase and up the other two in parallel. The stator circuits are not shown. The stator may, in order to reduce disturbance of the line at starting, be arranged in the well-known way for starting in star and running in delta; but this is applicable to all types and need not be considered here.

If the rotor has a three-phase winding it is obvious that one phase must carry the full exciting current, whilst the other two phases each carry half of it. Let n be the number of turns and ρ the resistance per phase, the the loss of power in the three phases when working asynchronously with a phase current I will be $3\,\rho\,I^2$, and the axial excitation will be $2\,n\,I$.

Let i be the direct current to produce the same loss; then we have

$$1{\cdot}5\,\rho\,n\,i^2 = 3\,\rho\,n\,I^2 \text{ and } i = \sqrt{2}\,I.$$

The exciter must therefore give about 40 per cent. more current than the normal slip-ring current in the asynchronous condition. The axial excitation produced will be about 5 per cent. greater, but as the rotor teeth must be well saturated there is no proportional increase in the field. On the other hand there is unequal local heating. To get over this difficulty the Oerlikon plan (Fig. 4*b*) is to arrange the winding in one phase in two parallels, each of $\frac{1}{2}\,n$ turns. Then the heating is uniform

all over the rotor and the excitation is the same as with alternating current. The exciting current is double the alternating-current slip-ring current. In the asynchronous condition the halving of the number of turns in one phase introduces some dissymmetry, but as there is always plenty of starting torque this is of no importance.

In a system devised by Messrs. Siemens-Schuckert (Fig. 4*c*) we find an attempt to reduce the magnitude of the direct current exciting current by providing a separate winding for excitation, having a larger number of turns than the three-phase winding. The rotor has salient poles, but with the pole-shoes so wide (95 per cent. of the pole pitch) that the starting winding, which is housed in the pole shoes, acts almost as in a motor with non-salient poles. The exciting winding is, as in any synchronous machine, placed on the magnet cores and the excitation is so great as to produce a high degree of saturation in the rotor teeth. At starting, a very high voltage is induced in the exciting coils, so that it is necessary to introduce for its protection a shunt resistance permanently coupled in parallel with it. This resistance has to be carefully selected so that on the one hand it shall lower the terminal voltage over the exciting coils sufficiently and, on the other, it shall not absorb too large a proportion of the power supplied by the exciter.

The exciting arrangements employed by the Metropolitan-Vickers Company have recently been dealt with in Mr. Carr's paper* and therefore need not be described in detail here. They are all more or less amplifications of the principle shown in Fig. 4*a*.

Messrs. Crompton use a two-phase winding on the rotor, with the star point carried to a slip-ring, so that, in all, three slip-rings are required. The advantage of this arrangement is that, although there may be a high voltage on the two outer slip rings, the voltage on the neutral or star slip ring, and therefore on one terminal of the exciter, is no higher than the exciting voltage, as will be seen on tracing out the exciter circuit (Fig. 4*d*). Thus the whole of the exciter is protected from the open-circuit slip-ring voltage. A further advantage is that the whole of the rotor copper is loaded to the same current density. The makers claim that the machine in its asynchronous condition will start against 2½ times full-load torque. The exciter is permanently in circuit and, by adjustment of its shunt rheostat, the leading power factor at various loads can be regulated.

The standard type of starting and synchronising gear used by the Lancashire Dynamo and Motor Company is shown diagrammatically in Fig. 4*e*. The rotor has also a two-phase winding, but with 120 deg. angular displacement of the phases, each acting at starting as an independent single-phase winding, whilst at synchronism the middle slip-ring is out of circuit so that the two windings give together an excitation equal to $\sqrt{3}$ times the ampere-turns of one phase. The change-over from the asynchronous to the synchronous condition is made *via* a "buffer resistance," as will be seen from the diagram.

By an ingenious arrangement of change-over switch gear the English Electric Company obtain the advantage of the full starting torque due to a three-phase rotor, combined with equal current loading in all the rotor copper when the rotor acts as a single-axis field magnet. The rotor has only two phases, but these may be coupled to form an open delta for starting, when the electrical angle between the two phases is 60 deg., and by reversing one phase the electrical angle may be altered to 120 deg. when the excitation given is $\sqrt{3}$ times the ampere-turns in one phase.

The arrangement is shown diagrammatically in Fig. 4*f*. There are four slip-rings marked *a*, a_1, and *b*, b_1, corresponding to the four terminals of the A and B phases (in open delta the third phase is omitted). To facilitate the tracing out of the connections the switch contacts are similarly labelled. The small key diagrams show vectorially the connections for "start" and "run." At starting the switch is on the lower contacts, and after all the starting resistance has been short-circuited the switch is thrown on to the upper contacts.

Fig. 4*g* shows diagrammatically the exciting circuit adopted by the General Electric Company for their synchronous induction motors. The rotor is star connected, and the connection with the exciter is such that one phase carries the total exciting current, whilst the other two phases each carry half that current. Strictly speaking, the one phase may therefore be called overloaded; but in reality it is not so. It would be more correct to say that the other two phases are underloaded. This is, however, an unavoidable consequence of the necessity of restricting the slip to a smaller value than in an ordinary induction motor in order to ensure quick and certain synchronising, so that the extra copper in the rotor would have to be provided in any case.

(To be continued.)

DEEPENING COLOMBO HARBOUR.—The Finance Committee of the Ceylon Legislative Council have approved the supplementary provision of Rs. 27,000 to meet the requirements of dredging in the harbour, in view of the provision being made to accommodate deeper draught vessels in the port and for the berths at the oil jetties. During August this year, says *Indian Engineering*, the dredger Sir William Matthews, dredged to a depth of 36 ft. below low water, and deposited at sea from the western entrance to the harbour a total of 29,900 cub. yards. The dredger Sir John Coode dredged to a depth of 33 ft. below low water at the approaches to the oil berths, and deposited at sea a total of 43,500 cub. yards.

* Journal I.E.E., 1922, vol. lx, page 165.

INGOT CORNER SEGREGATION IN A NICKEL CHROME STEEL.*

By T. HENRY TURNER, M.Sc., Assistant Lecturer and Demonstrator, University of Birmingham.

THE experiences to which reference is here made were mainly encountered in the examination of large and medium-sized steel forgings which had been received for machining at some of the most important engineering works in the country. The writer does not intend in this paper to deal with the manufacture of nickel chrome steel, but only to refer to experiences he has encountered in the examination of a variety of such steels in the machine shops, in successful service and after failure.

It should first of all be remarked that the failure of a nickel chrome steel part in service is generally of more serious and far-reaching consequences than is that of a straight carbon steel, since the nickel chrome steel will have been chosen by the designer on account of its special strength, and because the part in question will have been designed to be stressed more highly than is usual with parts made of carbon steels.

The increased efficiency of modern machinery has almost invariably been gained at the expense of higher speeds, lighter parts and greater stresses per square inch of the material employed. It is not surprising, therefore, that nickel chrome steels have failed at times in such highly stressed parts, since higher speeds have, in many cases, brought vibrational stresses, the nature of which could be calculated only with great difficulty, and often only approximately.

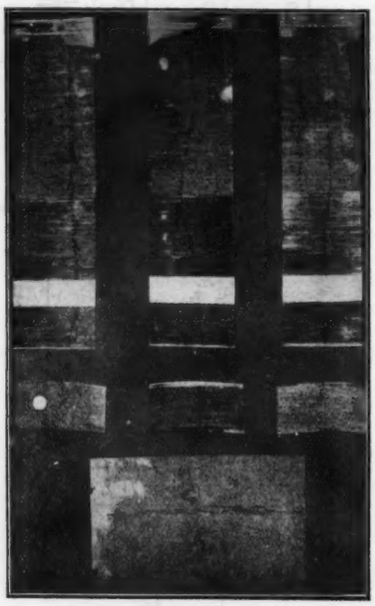


FIG. 1. Photograph of Sulphur Prints taken from First Forging Examined.

INGOT CORNER SEGREGATION.

(*a*) *Introduction.*—For some years past it has been the practice at the works to which the writer referred to scrutinise carefully all such highly-stressed parts. Any unusual markings noticed on the metallic surface has been examined. In this way the writer's attention was called to one or two faint markings on the machined surface of a hollow cylindrical bell, the dimensions of which were roughly 3 ft. in diameter, 1 ft. high, and 3 in. thick. On examining the marks more closely, he found that they extended in almost straight lines which ran the whole length of the cylinder. The regularity of these line markings showed that they were not ghost marks, and further examination brought out, in all, eight such marks spaced almost mathematically equidistant around the cylinder, and parallel to one another. The nature of the markings are shown in Fig. 1, which is reproduced from a photograph of the first sulphur prints taken from this forging. Prints A, B and C were obtained at three different places around the circumference of the cylinder. The white bands are due to a groove machined in the surface. Prints D, E and F reproduce the type of marking which was later detected at the end of the cylinder. Prints A and D indicated a line of segregation in two directions, and taken together they pointed to a plane of segregated material. The location of these planes of segregation suggested at once that their origin was due to the ingot mould, the conventional shape of which is frequently octagonal in the larger sizes. Further investigation showed that these planes of segregation extended to a depth of from 2 in. to 3 in. into the forging, and that they were to be found at places corresponding to the positions of all the eight corners of the original ingot mould form which the steel had been taken for forging.

Such being the apparent nature of the defects, the forging was discarded. Two replace forgings proved to have exactly similar markings, and were also discarded. A fourth and fifth forging had twin lines of segregation, V-shaped at the end and less definite in form than the fir-tree like segregation noted in the first forging, but still appearing at eight places equidistant from one another.

As it was decided to make a more complete examination of the nature of this segregation, the forging first examined was retained and cut up for the various tests reported later.

(*b*) *Initial Examination.*—On a freshly-machined surface the defects appeared as fine lines when viewed from the side, and as fir-tree like patterns at the end. Fig. 2 reproduces a photograph of eight sulphur prints taken from the end, and the similarity of segregation in each case will be noted. Sometimes these lines appeared to be fine cracks, but on filing, polishing and etching, the indication of a crack generally disappeared. It should be especially noted that the defects were only visible on a freshly-machined surface. This fact was emphasised when the customer's engineer visited the works to inspect the discarded forging. Every defect had been carefully located by lines drawn ½ in. on either side, and yet it was found impossible to detect any trace of the line of segregation on the slightly tarnished surface. Etching with nitric acid made no improvement, and it was necessary to file up the surface, and to take a sulphur print before one could demonstrate that any lack of homogeneity existed. However, this was clearly indicated by the sulphur print.

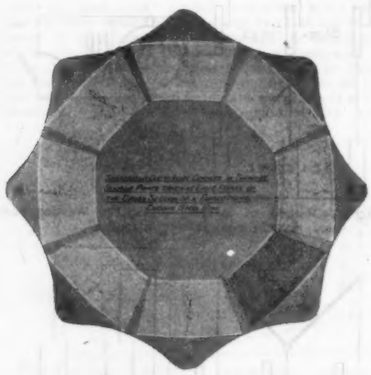


FIG. 2. Photograph of Sulphur Prints taken at Eight Points.

In connection with the case of segregation here reported, the writer made a search through the available literature for matter dealing directly with such a case. He also discussed the matter with the chief metallurgists of two of the leading Sheffield firms. Both of these gentlemen were well aware of the existence of such segregation, and recognised it as a defect over which the steel-maker has some control; they did not, however, give the writer any definite information as to the properties of such segregation when viewed from the engineering or users' point of view.

That the steel of an ingot varies considerably in its properties has been known for many years. So far back as 1878 the late Professor D. K. Tschernoff read a paper before the Russian Technical Society on the structure of cast ingots, in which he dealt with defects on steel castings such as piping, blowholes and segregation, giving such a picture of the crystallisation of a steel ingot that his paper became a classic.*

More recently Professor C. A. Edwards has dealt at considerable length with the same subject in Chapter VI of his book on the physico-chemical properties of steel.

Dr. J. H. Andrew published a paper in connection with J. N. Greenwood, M.Sc., and S. W. Green, on "Nickel Chrome Forgings" (Journal, I. and S. Inst., 1919, No. 11, vol. c, page 232). This deals with a somewhat similar steel and makes reference to ingot corner effects similar to those here discussed. These writers state that the quicker the metal can be made to solidify in the mould the better the properties of the casting.

A most useful bibliography of literature on relations of chemical composition and physical properties of iron and steel is given at the end of Dr. Stead's paper on the "Influence of Some Elements on the Mechanical Properties of Steel" (Journal, I. and S. Inst., No. 11, 1916).

In "Metallographic Methods for the detection of Phosphorus in Steel and Notes on Ghost Lines," Dr. Stead gave methods for the detection of local segregations of phosphorus in steel. (Proc. Cleveland Inst. of Engineers, December 14, 1914.)

Dr. Andrew McCance read a paper entitled "Non-Metallic Inclusions, their Constitution and Occurrence in Steel," and described the occurrence and segregations giving a most interesting series of photographs illus-

* Paper read before the Staffordshire Iron and Steel Institute at Dudley, November 18, 1922.

* See Proc. Inst. Mech. Eng., 1880.

trating various inclusions. He definitely stated that a high temperature of casting is beneficial in the production of steel free from inclusions.

The Brown Firth Research Laboratory contains a most interesting series of sections of steel ingots showing the location of piping.

But the writer has nowhere been able to find much reference to what he here names ingot corner segregation, and no reference to it has been noticed in engineering literature. Apparently this is a type of defect better known to the manufacturer than to the user, although its serious character makes it imperative that engineers be made aware of it.

(c) *Tests Undertaken.*—The existence of planes of segregation as indicated by the sulphur prints was not questioned by the steel makers, but little information appeared to be available as to the real nature of these planes, and as to their effect upon the mechanical or physical properties of the forging regarded as a whole. It was therefore decided to examine microscopically cross sections containing the segregation, this being particularly desirable since it was thought that minute cracks could be observed in the line markings. It was also decided to make chemical analyses and mechanical tests. To facilitate the cutting of the necessary test pieces, the hollow cylinder was first parted into five small rings, each approximately 1½ in. wide. These rings were numbered from the one end, S.R.1, S.R.2, S.R.3, S.R.4, S.R.5, and the lines of segregation were marked for identification. One of these small rings may be seen in Fig. 5A. It was thus possible to trace back every test-piece to its original position in the cylinder.

In every case a sulphur print was taken from the polished surface of the machined test-piece, and these were laid beside the test pieces after fracture. In practically every case where marked segregation was indicated by the sulphur print, the test-piece broke through that spot, although in some cases the fracture was not at the centre of the test-piece.

1. *Microscopic Examination.*—The material was examined microscopically both near to the segregated areas and in between them. Micro-photographs which were taken from the sections prepared showed that between the segregated areas the steel was a normal fine-grained and slag free sample, and that the segregation consisted largely of manganese sulphide, globules of which could be seen in a cross-section, strung out into a rough line.

A typical example of this is shown in Fig. 3A. Fig. 3C shows one of the slag globules at a greater magnification. Fig. 3B was obtained from the same specimen and illustrates the structure ½ in. to one side of the segregation, and although Fig. 3B is at double the magnification of Fig. 3A, no trace of sulphide can be seen. It is worth noting that the segregation does not form a continuous line, and an examination of Fig. 3A shows how it is possible apparently to detect a crack which vanishes entirely on filing off a few thousandths of an inch of the material, because the slight filing would remove the slag or crack and leave visible a layer of sound metal. Actual cracks did exist in the plane of segregation as shown in Fig. 4, which is a composite micro-photograph taken at 27 diameters. The discovery of this crack was especially disquieting, because as will be noted, it did not run out at the top, that is to the surface of the forging, and it could not therefore, be detected by the usual careful examination of the exterior. This particular crack started about 1/50th of an inch below the surface, and became discontinuous about ½ in. lower. Further smaller cracks could be observed below this point, making an almost complete plane of weakness through the cylinder at this point.

2. *Chemical Tests.*—Drillings were taken from three forgings of this type. The analyses are tabulated below. These analyses are so nearly similar that it would appear that all three rings were produced from the same heat of steel, and probably from the same ingot. The steel-makers have confirmed this. An attempt was made to determine the chemical properties of the segregated areas, and drillings were taken at a number of small holes along one of the lines of segregation. Check drillings were taken in the unsegregated portion. These gave the analyses shown in the next column.

——	Forgings Marked		
	B.R.1.	B.R.2.	B.R.3.
C	0·23	0·24	0·22
Si	0·11	0·14	0·11
Mn	0·37	0·39	0·39
S	0·027	0·034	0·036
P	0·036	0·030	0·043
Ni	3·27	3·29	3·33
Cr	0·43	0·49	0·45

From this it would appear that the segregated areas are somewhat higher in sulphur and phosphorus and lower in chromium. The other figures are so similar that practically no difference can be said to exist, and an examination of the actual sulphur print shown will indicate that such drillings would inevitably include a very large proportion of normal material, however small a drill were employed.

——	Segregated.	Un-segregated.	Per Cent. Difference.
C	0·223	0·242	− 7·0
Si	0·105	0·098	+ 6·0
Mn	0·43	0·42	+ 2·0
S	0·034	0·030	+11·0
P	0·054	0·045	+16·0
Ni	3·57	3·55	+ 0·5
Cr	0·33	0·47	−30·0

FIG. 3A. Micro-Photograph of Segregation × 50 Diameters.

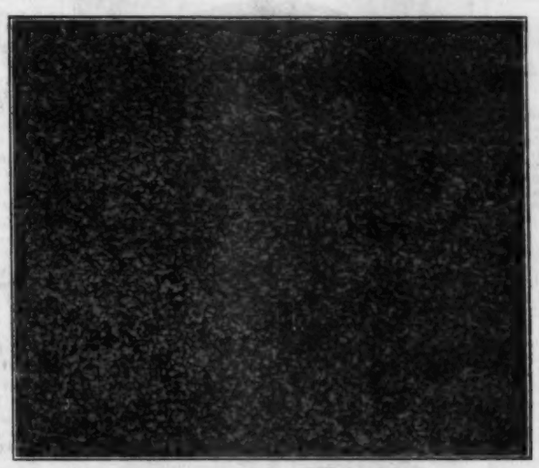


FIG. 3B. Micro-Photograph of Material Half-an-Inch to One Side of Segregation shown in Fig. 3A × 100 Diameters.

FIG. 3C. Micro-Photograph of Slag in Segregation × 130 Diameters.

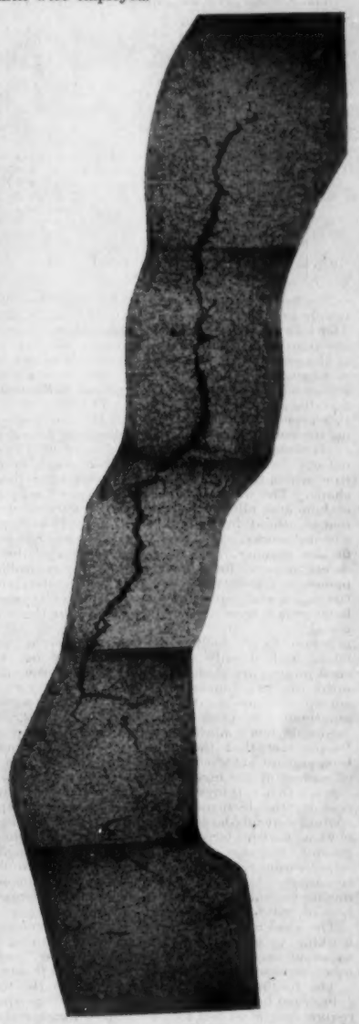


FIG. 4. Composite Micro-Photograph of Crack in the Plane of Segregation reproduced at × 27 Diameters. N.B.—Crack does not extend to the Surface of the Forging.

3. *Mechanical Tests.*—(1) To determine the nature of the normal material, test pieces were cut between the lines of segregation and gave the following results :—

Tensile	Ultimate tensile strength, 41·2. Yield-point, 33·1. Elongation per cent. on 2 in., 25·0. Reduction in area, 57·0. Fracture normal.
Bend	180 deg. without fracture.
Izod	Average 51 ft.-lb.
Brinell hardness ..	197.

(2) To determine the nature of the segregated material test pieces were cut from the small rings S.R.1, S.R.3 and S.R.5, representing the two ends and the middle of the original cylinder. In each case the test pieces were cut across the segregation marked No. 1 ; the bend test-piece across No. 8 ; the Izod test-piece across No. 4. In the case of S.R.3, the section allowed the cutting of two test pieces, of which the outer was stamped A,

while that nearer the centre of the ring was stamped B. These results were as follows :—

	S.R.1.	S.R.3.A.	S.R.3.B.	S.R.5.
U.T.S.	27·4	40·4	33·2	36·5
Y.P.	No yield observed	32·85	32·9	33·6
Elongation per cent. ..	None	10·0	None	None
Reduction in area ..	2·7	4·3	3·0	3·5
Bend broke at	10 deg.	15 deg.	60 deg.	15 deg.
Brinell hardness ..	197	207	183	197
Izod	46·5	18·0	44·5	15·2

(3) To determine the nature of the segregation at any complete circumference of the ring, tensile and bend test pieces were cut at each of the eight places marked on S.R.2.

These tests gave the following results :—

Test-Piece from Defect No.	Brinell Hardness.	Bend Test.	U.T.S.	Y.P.	Elongation per Cent.	Reduction in Area.	Fracture.
		deg.					
1	197	180 O.K.	41·7	32·8	28·0	61·5	Normal.
2	197	75 Broke	38·3	31·9	5·0	8·0	Slatey.
3	197	45 Broke	41·6	33·5	7·0	11·6	Slatey.
4	197	40 Broke	41·0	32·9	7·5	8·0	Slatey.
5	197	50 Broke	34·0	31·8	3·0	8·0	Slatey.
6	187	180 O.K.	39·9	31·3	17·0	21·3	Slatey.
7	187	180 O.K.	40·3	31·3	27·0	61·5	Normal.
8	197	15 Broke	32·5	No yield observed	1·0	5·0	Slatey.

Fractures.—The nature of the fractures of all the tensile and bend pieces is shown in Figs. 5A, 5B and 5C. The fact that no plastic flow has taken place and that the fracture is similar in appearance to that of a piece of slate is here shown. Actually such fractures appeared non-metallic, being somewhat dull, strata-like, and a greenish yellow in colour, as opposed to the usual bright metallic grain of fibre fractures. The connection between this type of brittle fracture and the markings observed on the sulphur prints was conclusively demonstrated.

(*d*) *Origin of Defects and Influence of Design.*—The defects described above have their origin in the ingot from which the steel was taken for forging to the required shape. The writer has seen this type of segregation in carbon and alloy steel forgings of various dimensions manufactured in a number of both British and Continental works. However, all ingots are not segregated in this manner, and steel-makers accept this type of defect as one for which they are responsible. Such planes of segregation occur at the angular portions of the ingot and represent the meeting of crystals which have grown from the cooling faces into the still liquid metal.

Non-metallic bodies having a different crystalline form, and usually a lower melting-point than the steel proper, are pushed forward by the growing crystals until the two planes of crystal growth meet, and so entrap the non-metallic bodies in positions which lie practically in planes bisecting the angles. That all ingots do not contain such planes of segregation is due to the fact that the shapes of the ingot mould, the temperature at which the steel is poured, and the rate of cooling of the ingot, all affect the nature of the solid ingot. Other things being equal, the more rapid the cooling, the less the segregation, and, as rapidity of cooling depends largely upon the size of the ingot, it is obvious that all large ingots will be more liable to segregation. Rapid cooling of the outside of an ingot during solidification tends to prevent the segregation of impurities there. Unfortunately, however, the danger of producing cooling cracks increases with the increase in the rate of cooling.

The steel-maker's practice requires, therefore, careful working between definite temperature limits, in order to avoid on the one hand cracked ingots, and on the other hand segregation of the character here described.

The forgings examined were made in the form of a cylindrical bell and were of a size and shape that would require special tools if they were to be forged out approximately to their finished form. We understand that such tools were not available (due apparently to the small demand for the type of forging in question) and that therefore the ingot used was submitted to only a limited amount of forging in reducing it down to a solid cylinder from which the interior was later removed by machining. Thus the extent of the forging done was small compared with that involved in producing a plain ring, and as the greater part of the interior metal was removed, it left the ingot corner trouble extending practically through the thickness of the hollow cylinder described. Forgings on which more work had been possible did not show such definite lines, and in cases where the defect was present it was much less distinct, and was not so deep as in the case of the type of forging under investigation.

(*e*) *Recommendations.*—The following recommendations are offered in the hope that they will assist the users of large forgings.

1. That the bell-shaped cylinder design should never be used unless the supplier can guarantee :—

(*a*) Absence of planes of segregation in the material.

(*b*) Adequate working during the forging operations.

2. That in cases where the supplier cannot guarantee adequate working of the material during forging (owing to the nature of the design and the limitations imposed upon his work by the nature of his available tools), a composite ring made up of two or more rings, which can be manufactured by a satisfactory forging or rolling, would probably prove more reliable.

3. That the final rolling of such rings is to be preferred to forging them throughout, in that it would tend to produce greater uniformity of dimensions in the rough, and therefore economy in machining. Also it should produce a better and more uniform internal structure and greater uniformity of mechanical properties.

4. That in the case of all large forgings which will be subjected to appreciable circumferential loading, the supplier should be asked to face up both ends of the block of steel before forging is commenced. Sulphur prints should then be taken and forging only proceeded

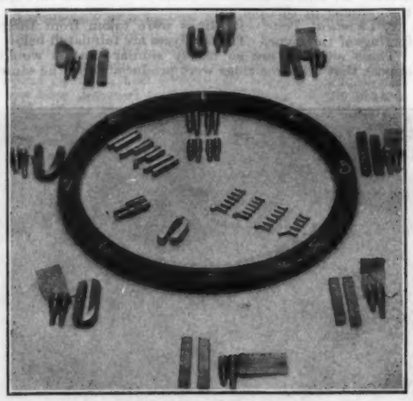


FIG. 5A. Photographs of Fractured Test Pieces.

FIG. 5B. Photographs of Fractured Test Pieces.

FIG. 5C. Photographs of Fractured Test Pieces.

with after these have been passed as satisfactory. Such an operation would, of course, be costly, but it would only be advisable when appreciable hoop stresses are expected.

5. That in cases where the steel-maker considers recommendation No. 4 impracticable, the elimination of ingot corner segregation may be achieved by forging down octagonally and machining off the corners which would still contain the segregation. This suggestion is perhaps the most useful and that most likely of successful adoption.

6. That the centrifugal casting of steel for such large cylinders or rings, and even for large turbo-generator rotors, is feasable and worthy of serious consideration.

(*f*) *Summary.*—The rejection of the forgings examined was fully justified, because although the mass of the material possessed good chemical and mechanical properties, the defects, consisting in planes of segregation, entirely negatived these good properties, and made the forging as a whole treacherous and unreliable in the extreme. The value of sulphur printing as a method of examination in such cases was emphasised by its very successful use in this investigation.

Users of large forgings must beware of ingot corner segregation.

(*e*) *Conclusion.*—The writer, therefore, suggests that one should first study the matter theoretically and so, it is to be hoped, learn to avoid the production of such planes of segregation by the use, perhaps, of new mould shapes, better regulated pouring rates and temperatures, or even by centrifugal casting.

Also the elimination of danger from such segregation, if accidentally present, may be possible by the use of special methods of forging and machining.

Lastly, he would suggest that the user may always detect such defects by sulphur prints and mechanical tests taken so as to cut across the material which originally formed the ingot corners.

CATALOGUES.

Air Humidifier.—An apparatus for supplying moistened air, cooled or heated, to factories or other places is the subject of a small special catalogue issued by Messrs. Cleworth, Wheal and Co., Limited, Castleton, Lancashire.

Screwing Tools.—A very complete and well-arranged catalogue of taps, dies, die-nuts, wrenches and stocks comes from B.S.A. Tools, Limited, Sparkbrook, Birmingham. Some useful technical tables are included for reference.

Gas Meters.—The Cutler Hammer Manufacturing Company, 50, Church-street, New York, send us several interesting catalogues of apparatus for measuring and recording the volume of gas and air and also calorific values of gases.

Switch Gear.—A new catalogue with priced lists and full particulars of ironclad oil break switch pillars of standard unit construction has been issued by the English Electric Company, Limited, Queen's House, Kingsway, London, W.C. 2.

Mechanical Stoker.—The Riley stoker for water-tube boilers is very clearly described in a catalogue issued by Messrs. Charles Erith and Co., Palace Chambers, Bridge-street, London, S.W. 1. In this stoker the coal is fed upward through the fire.

River Craft.—Mr. Arthur R. Brown, 54, New Broad-street, London, E.C. 2, has sent us a comprehensive catalogue of dredgers, river steamers, tugs, lighters, &c., designed and supplied by him and including a number of dredgers for gold, tin and platinum.

Gearing.—A catalogue covering the whole range of ordinary tooth gearing—spur, bevel, worm, skew, racks, &c.—comes from Messrs. Crofts, Limited, Bradford, who make any required wheels or sets and also a considerable range of completely-enclosed transmission units.

Electric Generators and Motors.—The A.C.E.C. Company of Belgium (56, Victoria-street, S.W. 1) send a copy of their list of alternating-current and direct-current generators and motors kept in stock ready for delivery. The list includes over 1,100 different machines.

Vacuum Dust-Handling Plant.—A complete plant for cleaning boiler flues, and conveying fine materials by pneumatic suction is described in a special catalogue received from the British Vacuum Cleaner and Engineering Company, Limited, Parsons Green-lane, London, S.W. 6.

Wireless Apparatus.—A set of standard parts for wireless telegraphy or telephony suitable for erection and use by amateurs has been made by the British Insulated and Helsby Cables, Limited, Helsby, near Warrington, who send a new catalogue with illustrations and prices.

Condensing Water Treatment.—A reprint of an interesting paper by Mr. L. L. Robinson, on the chemical treatment of condensing water to prevent the fouling of condenser tubes has been issued by the Paterson Engineering Company, Limited, Windsor House, Kingsway, London, W.C. 2.

Air Pumps.—An 84-page book describing the design and methods of operating and maintaining their "Radojet" air pump, has come to hand from Messrs. John Musgrave and Sons, Limited, Bolton. The technical information given is considerable, and refers to a variety of service conditions.

Electric Drive for Textile Mills.—A comprehensive account of the application of electric motors to the driving of textile mill machinery is given in a catalogue issued by the British Thomson-Houston Company, Limited, Rugby. The generating plant, the distribution of the current, and the arrangement of motors for various departments and machines are all explained, and many excellent illustrations given including plans of mills fitted up by the firm both as new installations and as conversions from steam-engine drive.

Heavy Oil Engines.—A catalogue of horizontal heavy-oil engines giving a full specification with illustrations of parts and all necessary technical and commercial information, is to hand from Messrs. Tangye's, Limited, Birmingham. Thirteen sizes are listed with single cylinders, ranging from 18 b.h.p. to 125 b.h.p., for general work, together with a second series in the same powers for driving electric generators; double cylinder engines, ranging from 50 b.h.p. to 250 b.h.p. in both types, are also listed. In all cases the indicated horse-power on test is about one-fifth more than the brake horse-power, the tests being made with oil having a calorific value of 18,000 B.Th.U. per pound and specific gravities up to 0·95. The engines are of the cold starting type and consume residual ordinary or refined oils. They can also be arranged for running on tar oils or alcohol, and if necessary for using gaseous or liquid fuels alternatively.